THE JOURNAL OF THE ALABAMA ACADEMY OF SCIENCE

VOLUME 79 JANUARY 2008 NO. 1

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On behalf of the Alabama Academy of Science, I would like to express my gratitude and appreciation to the following for their valuable contributions in reviewing the manuscripts of this issue:

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THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE
AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 79 JANUARY 2008 NO.1

Publication and Subscription Policies:
Submit all manuscripts and pertinent correspondence to the Editor. Each manuscript will receive at least two simultaneous reviews. For style details, follow instructions to Authors (see inside back cover).

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ISSN 002-4112

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CONTENTS

Journal of Alabama Academy of Science Vol. 79, No. 1, January 2008

DISTRIBUTION OF CANEBRAKES IN 19TH CENTURY ALABAMA

John A. Barone, Jessica W. Beck, Matthew B. Potter, Susan R. Sneed, Karen E. Stephenson and Edgar J. Dollar II

Department of Biology, 4225 University Ave., Columbus State University, Columbus, Georgia 31907-5645

Correspondence: Barone, J. A. (barone_john@colstate.edu)

ABSTRACT

Canebrakes are single-species stands of *Arundinaria gigantea*, a native bamboo of the southeastern United States. Though canebrakes are now considered an endangered ecosystem, little is known about their historic distribution. Early survey maps and other historical sources were examined to determine the extent and location of canebrakes in 19th century Alabama. About 78,900 hectares of canebrakes or probable canebrakes are indicated on the survey maps. These canebrakes were located predominately in the floodplains of the Alabama and Black Warrior rivers and their tributaries, with the greatest concentrations in Lowndes, Dallas, Wilcox and Marengo counties. A comparison of these canebrakes with a soil map of the state suggests that large canebrakes were most common on alluvial soils of river terraces as well as nearby slopes. Historical sources, such as travelogues, journals and diaries, confirm the presence of extensive canebrakes in this part of the state but also suggest that other large canebrakes were likely present along the Mobile and Tombigbee rivers and across much of the Black Belt. Canebrakes appear to have been present but scarcer in the northern part of the state.

INTRODUCTION

Arundinaria gigantea (Walter) Muhl. is a native bamboo of the southeastern United States that frequently grows in dense, single-species stands called canebrakes (Hughes, 1951; Meanley, 1972; Marsh, 1977; Judziewicz *et al.*, 1999). Growing from an underground stem, the upright culms or "canes" of *A. gigantea* can reach a height of 8m with a diameter of 2cm (Hughes, 1951; Meanley, 1972; Judziewicz *et al.*, 1999). The density of canes in a canebrake can reach 49,000 per hectare, though the understory is often open because of the thickness of the evergreen canopy and occasional flooding (Meanley, 1972). Contemporary canebrakes are typically found in mesic, fertile soils and are most common in elevated terraces along rivers where flooding is rare (Judziewicz *et al.*, 1999). Historically, a variety of animals have used canebrakes as habitat, including bison, swamp rabbit, canebrake rattlesnake, black bear, and Bachman's warbler (Remsen, 1986; Platt *et al.*, 2001).

Extensive canebrakes of *A. gigantea* covering many hectares were a common

feature of the historic landscape of the Southeast. A second species of cane, *A. tecta* (Walter) Muhl (sometimes regarded as a subspecies of *A. gigantea*) also occurs in the region and may also have been present in historical canebrakes. Over the last two centuries, these canebrakes have been mostly eliminated by ranching and agriculture (Hughes, 1966; Platt and Brantley, 1997; Brantley and Platt, 2001; Ethridge, 2003; Stewart, 2007). Noss *et al.* (1995) suggest that canebrakes have experienced a 98% decline in abundance since European settlement, making them a critically endangered ecosystem. However, little is known about either the current (Brantley and Platt, 2001) or the historical extent and distribution of canebrakes for any part of the Southeast.

Early government land surveys are an important source of information on historic vegetation in the United States (Whitney and DeCant, 2001). For most of the southeastern states, these surveys were conducted by the federal General Land Office (GLO) in the first half of the 19th century. Maps and notes produced during these surveys have been used by ecologists to describe a variety of historical landscapes (e.g. Delcourt, 1976; Schafale and Harcombe, 1983; Nelson, 1997; Bragg, 2003). Despite a variety of limitations (Noss, 1985; Whitney and DeCant, 2001), these surveys provide a starting point for developing maps of historical vegetation, including canebrakes.

The goal of this study was to characterize the distribution of historic canebrakes in Alabama. Three approaches were used. First, data from early land surveys were compiled to create a map showing the location and extent of canebrakes in the first part of the 19th century. Second, this map was compared to a detailed soil map to determine what types of soils and circumstances favored the growth of extensive historical canebrakes. And third, other types of historical sources, such as letters, diaries, and travelogues, were reviewed for accounts of the location and size of historic canebrakes. Such sources confirmed the existence of many canebrakes on the survey maps and established the presence of canebrakes in other parts of the state.

MATERIALS AND METHODS

Data to create a map of historic canebrakes were taken from survey or plat maps produced by the GLO as part of the initial land surveys of Alabama conducted from the 1810's to the 1840's. In its surveys, the GLO used a rectangular mapping system that laid out six by six mile (9.7 by 9.7 km) townships in a grid across the state (Whitney and DeCant, 2001). As part of the surveys, a plat map was produced for each township, and these often included landscape features such as streams, rivers, swamps, prairies, and canebrakes (Whitney and DeCant, 2001). Areas of canebrakes on the plat maps show up as irregular, enclosed shapes, labeled by either the word "cane" or "canebrake."

Digital versions of the plat maps for Alabama were accessed at the United States Bureau of Land Management website (http://www.glorecords.blm.gov). Every plat map for the state was examined. Plat maps that showed canebrakes were downloaded as MrSID files and then georeferenced using the Geographic Information Systems program ArcMap (ESRI, Redlands, CA). Areas of canebrake were then traced using ArcMap to create shape files which, in turn, were merged to make a composite map showing areas of canebrake for the state at the time the surveys were conducted. The areas of the canebrakes

were calculated from this map using ArcMap.

Soil map data for Alabama were produced by the Natural Resources Conservation Service (2006) and were downloaded from its website (http://soildatamart.nrcs.usda.gov). The distribution of canebrakes was examined across the entire state to determine the general soil conditions that favored growth of large historic canebrakes.

A thorough search of historical sources for references to canebrakes in Alabama was conducted. The list of relevant citations in Platt and Brantley (1997) was expanded upon by including additional pamphlets, journals, letters, diaries, scientific publications, histories, memoirs, travelogues and gazettes. The search was limited to sources from the 18th and 19th centuries and emphasis was placed on eyewitness descriptions of canebrakes from known locations.

RESULTS AND DISCUSSION

Based on the plat maps from the GLO surveys, about 54,700 hectares of canebrake existed in Alabama from the 1810's to 1840's, with the largest areas along the Alabama and Black Warrior rivers and their tributaries, in central and west-central Alabama (Figure 1). However, an additional 23,600 hectares of probable canebrakes were observed on the plat maps. This figure is for areas that were unlabeled but contiguous with labeled canebrakes on neighboring plat maps. In some cases, no areas of canebrake are indicated on adjacent plat maps. As a consequence, some canebrake areas on Figure 1 have straight edges (e.g. northern Marengo County). An additional 600 hectares on the plat maps were labeled as being a mix of canebrake and other species, such as oaks. Thus, in total about 78,900 hectares of canebrakes, probable canebrakes and mixed canebrakes are indicated on the plat maps.

A comparison of these canebrakes with the soil map shows that about 87% of the large, historical canebrakes were found on four general soil map units, consisting of 15 soil series (Table 1). These soil series all have moderately deep to very deep soils and are well-drained (Natural Resources Conservation Service, 1998). Most of these soils are typically found along rivers and streams, in flood plains or low terraces (e.g. Urbo-Mantachie-Izagora-Chrysler) but are subject only to brief, occasional flooding (Natural Resources Conservation Service, 1998). However, some of the soil series, such as the Luverne and the Oktibbeha, are usually found on ridgetops and side slopes. Together, these results suggest that canebrakes in 19th century Alabama were most common near rivers and streams, though in areas not subject to frequent floods, and that the canebrakes would sometimes extend upward onto adjacent slopes and ridges.

One notable feature of the historic distribution of Alabama canebrakes on the plat maps is that none are located in the northern half of the state. Limitations of survey data may explain this (see below). Nonetheless, with the exception of a small area along the Cahaba River in Bibb County, none of the soils apparently favored by canebrakes are found in the northern half of the state. Indeed, the two dominant soils map units for canebrakes, the Vaiden-Sumter-Oktibbeha and the Luverne-Halso-Conecuh, are found exclusively in the Black Belt and in the northern Timber Belt immediately to the south. Apparently, historic canebrakes were most common in the coastal plain of Alabama.

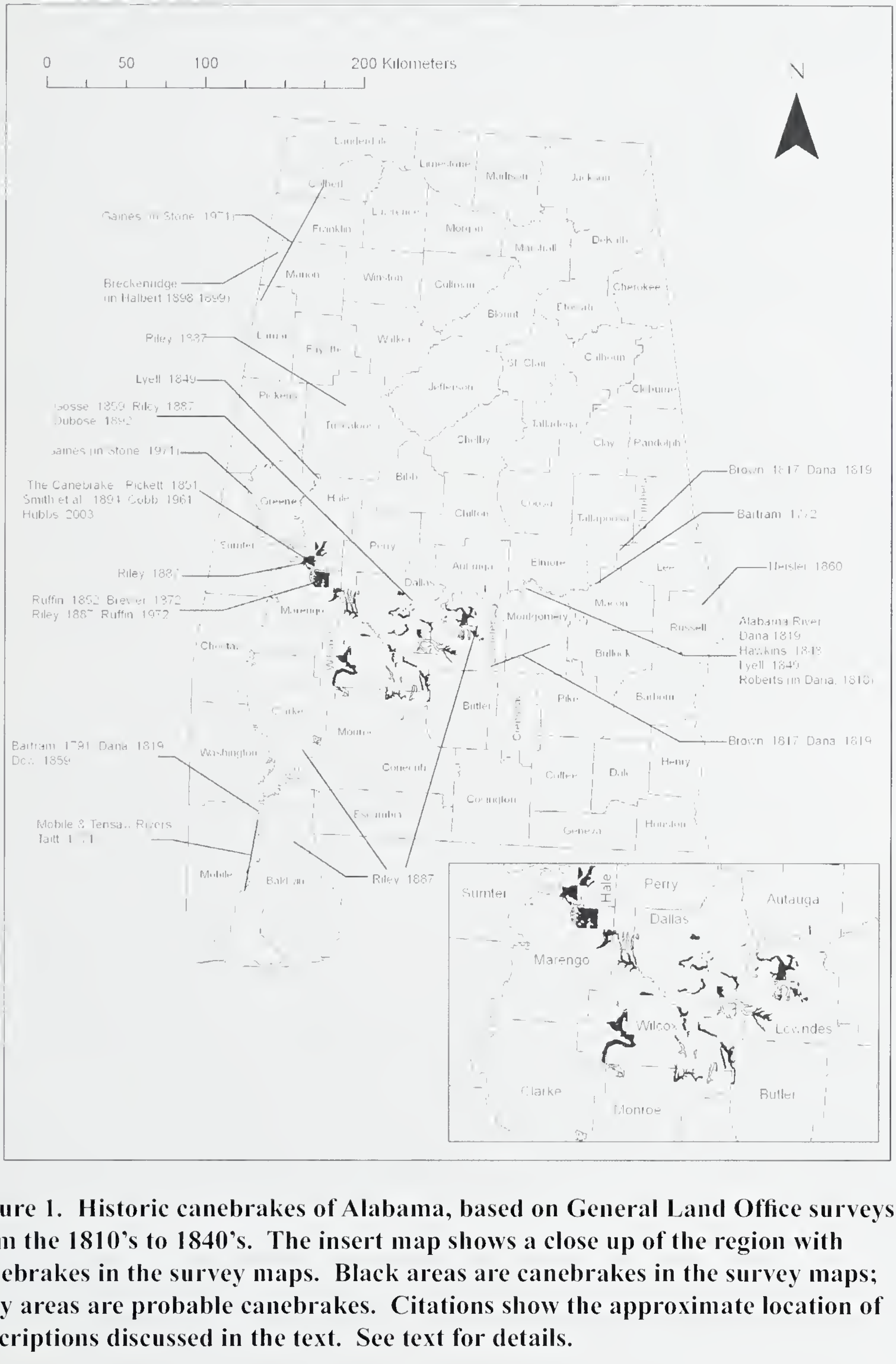

Figure 1. Historic canebrakes of Alabama, based on General Land Office surveys from the 1810's to 1840's. The insert map shows a close up of the region with canebrakes in the survey maps. Black areas are canebrakes in the survey maps; gray areas are probable canebrakes. Citations show the approximate location of descriptions discussed in the text. See text for details.

Table 1. Areas of canebrake according to soil map unit, based on General Land Office Plat maps. About 87% of the area of canebrakes were found in the top four general soil map units.

General Soil Map Units	Hectares
Vaiden-Sumter-Oktibbeha	33932
Luverne-Halso-Conecuh	16234
Urbo-Mantachie-Izagora-Chrysler	9300
Riverview-Minter-Leeper-Canton Bend-Cahaba Annemaine	8939
Malbis-Lucedale-Bama	3359
Mantachie-Lenoir-Leeper-Houlka	1201
McQueen-Houlka-Bama	995
Savannah-Quitman-Mashulaville-Bama	938
Vaiden-Minter-Kipling-Angie	883
Urbo-Una	753
Water	673
Mantachie-Lenoir-Iuka-Bibb	575
Mantachie-Ellisville-Cahaba-Adaton	323
Sumter-Scarcy-Oktibbeha-Demopolis-Congaree-Brantley	156
Watsonia-Troup-Smithdale-Prim	148
Vaiden-Sumter-Faceville	136
Harleston-Escambia-Bayou	113
McQueen-Mantachie-Goldsboro-Congaree	80
Myatt-Mantachie-Kinston-Iuka-Bibb	47
Orangeburg-Luverne-Conecuh	46
Rains-Bonneau-Bethera-Benndale	38
Troup-Saffell-Orangeburg-Dothan	10
Luverne-Lucedale-Bama	9

However, the data from GLO surveys have many limitations when applied to ecological situations (Noss, 1985; Whitney and DeCant, 2001). In the present study, three issues are particularly important. First, the quality of the plat maps for the state is variable. While some maps, especially those for the Black Belt across central Alabama, include numerous landscape features, such as prairies and canebrakes, many plat maps are blank except for the locations of streams and rivers. Consequently, many canebrakes observed by surveryors were likely omitted from these maps. Second, errors in the placement of the canebrakes, either by the original surveyors or by the authors when georeferencing the plat maps, would have led to distortions of either the size or location of canebrakes. Third, there is no way of determining if the canebrakes observed by the surveyors were uniform stands of *Arundinaria gigantea* or whether other species were common. For these reasons, the areas and locations of canebrakes in Figure 1 must be regarded as tentative.

A variety of other historical sources confirm the existence of the large canebrakes indicated on the plat maps, as well as additional canebrakes in other parts of the state. These historical sources are reviewed below. The approximate locations described in these sources are shown on Figure 1.

Several authors note that the area from southern Greene County to northwestern Dallas County was often referred to as "the Canebrake" in the 19th century (Pickett, 1851; Smith *et al.*, 1894; Cobb, 1961; Hubbs, 2003). Benjamin Riley (1887), author of several

books on the history of Alabama, noted that "the canebrake lands of Marengo are found in the northern end of the county and extend southward about ten or fifteen miles" and that "along the streams are dense brakes of cane." In his 1858 diary, the agricultural reformer and politician Edmund Ruffin (1972) also mentioned canebrakes in Marengo County: "I went home with Mr. Richard Adams, who resides in Marengo, in the midst of the best body of the cane-brake lands." In a separate work, Ruffin (1852) wrote on the soils of Alabama and says that "A [soil] specimen of the very rich 'cane brake' lands in Marengo County, Alabama, contained sixteen per cent of carbonate of lime." W. Brewer (1872), an Alabama lawyer and congressman, in describing Marengo County, said that "the northern part is the canebrake region, a district extending over nearly three hundred square miles," and that it is "covered with a thick growth of cane of marvelous size, and almost devoid of other vegetation." This area of canebrake extended northward into southern Hale County on the plat maps. Riley (1887) observed that the southern portion of Hale County "is composed almost entirely of black canebrake land, which has a marvelous fertility." These descriptions confirm the presence of canebrakes seen on the GLO plat maps.

Significant areas of canebrake were observed elsewhere in the Black Belt. The British naturalist Philip Henry Gosse (1859), who stayed in Dallas County in 1838, found that "The steep banks of many of the winding creeks and branches are densely clothed, for considerable portions of their darkling course, with tall canes . . . .When the country was first settled, the cane-brakes were much more extensive, and only penetrable by means of the axe." Riley (1887) also provided a brief description of the canebrakes in Dallas County: "In the western portion of the county is the famous canebrake region. . . ." John Witherspoon Dubose (1892), in a biography of Alabama politician William Lowndes Yancey, commented that in 1836-1837 in Dallas County, "Hundreds of wagon loads of cotton bales, each drawn by six great mules, over roads cut through the towering cane, walling the impenetrable sides, came to Cahawba." Riley (1887) also confirmed the presence of canebrakes in neighboring Lowndes County: "[T]he dense brakes of cane, which prevail along the streams and in the marshy lowlands, make this one of the most desirable sections for stockraising."

Historical sources also describe large canebrakes that do show up on the plat maps, such as at the eastern end of the Black Belt region. In 1798, Benjamin Hawkins (1848), the United States Indian Agent, observed that the village of Ecunchate along the Alabama River, site of present-day Montgomery, was "on the right side, in the cane swamp." He also noted that in what is now north Montgomery County "in the fork of the two rivers, Coo-sau and Tal-la-poo-sa, where formerly stood the French fort Toulouse," there was "a flat of low land of three thousand acres, which has been rich canebrake; and one-third under cultivation, in times past; the centre of this is rich oak and hickory, margined on both sides with rich cane swamp." Charles Lyell (1849), the prominent Scottish geologist, visited central Alabama in 1846. During a steamboat ride from Montgomery to Mobile, he observed that "The banks of the Alabama, like those of the Savannah and Alatamaha rivers, are fringed with canes, over which usually towers the deciduous cypress, covered with much pendent moss." E. Dana (1819), who explored much of the Southeast during the early 19th century, explained that "Bordering on the Alabama [River], are cane swamps, interspersed

with pine flats, covered with soil suitable for sugar, cotton or corn." W. Roberts (in Dana, 1819) worked as a surveyor in central Alabama. In describing streams of Montgomery County, he said: "The principal of these are the Catoma, Pinkahna, Pophlahla and Big Swamp creek, all of which afford extensive bottoms of rich cane brake and beech swamp." As part of a description of the Alabama River in the central Black Belt, Roberts (in Darby 1818) commented that "The river cane bottom land, we suppose to be equal in fertility to any on the continent, and may average in width a half to three-quarters of a mile; the river winding through it in a serpentine course, leaving the cane land sometimes on this side and sometimes on that." About the same region, Dana (1819) wrote: "Between the dividing ridge that separates the waters of the Cunecuh from those of the Alabama, and the latter river, is a tract of rich land, about 30 miles long and 20 wide; the timber of a large growth, and the cane abundant. . . ." Samuel Brown (1817) mentioned the same area: "Proceeding towards the dividing ridge between the Alabama waters and those of the Conecah, we pass over an extensive tract of rich land, the timber large, and cane abundant, thirty miles long and twenty miles wide."

Several sources suggest that canebrakes were extensive in Elmore County and further north. Willam Bartram (1791), the famous botanist, wrote of his visit to the area: "July 13th, we left the Apalachucla town, and three days journey brought us to Talasse, a town on the Tallapoose river, North East great branch of the Alabama or Mobile river, having passed over a vast level of plain country of expansive savannas, groves, Cane swamps and open Pine forests." Dana (1819) described an area 60 miles (97 km) north of where the Coosa and Tallapoosa Rivers combine: "The streams are margined with cane." Brown (1817) remarked on the presence of cane in this same area.

Neisler (1860), a Georgia botanist, briefly notes that he had observed large cane in Russell County: ". . .whilst I have seen occasional [cane] specimens cut from the swamps of the Uchee in Alabama, which, though not actually measured, I should judge, could not have fallen short of forty feet."

Except for a single patch in northwest Marengo County, no canebrakes show up on plat maps of townships arrayed along the Tombigbee, Tensaw or Mobile Rivers in the southwestern portion of the state. However, a variety of other historical sources make it clear that canebrakes were abundant along parts of these rivers. For example, David Taitt (1771) produced a map, based on his own surveys, of the areas adjacent to these rivers. According to this map, extensive areas of canebrake were present on both banks of the Mobile River, up to about 30 km from its mouth. The largest of these canebrake areas was near Mobile Bay, extending about 16 km from the bay, with a maximum width of about 3 km. Similar large canebrakes are also shown on both banks of the Tensaw River. As on the Mobile, these canebrakes did not extend much more than 29 km from Mobile Bay. However, further north on the map the words "large canes" appear in an area that lies between Gumpo Lake and Tensaw Lake, about 10 km east of Mt. Vernon, in Baldwin County.

Other written sources confirm the presence of canebrakes in this part of the state. On Baldwin County, Riley (1887) wrote: "Along the streams and in the swampy lowlands there are extensive districts of luxuriant wild cane. . . ." Northward, in Clarke County,

Riley (1887) observed that "Along the streams are dense thickets of cane."

Lyell (1849) traveled by steamship from Mobile to Tuscaloosa up the Tombigbee and Black Warrior Rivers and noted that "We admired the canes on the borders of the river between Tuscaloosa and Demopolis, some of which I found to be thirty feet high." Riley (1887), described canebrakes in Tuscaloosa County: "In low places, usually along the creeks, are found dense brakes of wild cane, which is greatly relished by stock."

In 1808, Edmund Pendleton Gaines (in Stone, 1971a) traveled down the upper Tombigbee River from Monroe County, Mississippi, to the river's intersection with Noxubee Creek, in Sumter County, Alabama. In his survey diary, Gaines made 140 notes of canebrakes over 138 river miles. All are very brief, such as "thick Cane-brake both sides [of the river]" and "Rich Cane-brake low grounds on left & right". These notes make it clear that canebrakes were ubiquitous along the river, except in areas with high bluffs.

Bartram (1791) observed cane along the upper Tensaw River: "These islands exhibit every shew of fertility, the native productions exceed any thing I had ever seen, particularly the Reeds or Cane (*Arundo gigantea*) grow to a great height and thickness." Near the confluence of the Alabama, Mobile and Tensaw Rivers, he saw ". . .Canes and Cypress trees of an astonishing magnitude, as were the trees of other tribes, indicating an excellent soil." In the same area, Dana (1819) saw that "Along the Tensaw, are many pine and cypress trees; near the river are canebrakes and some cypress swamps." He added: "Adjacent to the swamps, for a mile in width, is a sterile, stiff clay; the growth, pine and underbrush; further back, are broken pine barrens; and on the streams, cypress ponds and cane brakes." The Reverend Lorenzo Dow (1859) traveled through this same region. He left from "the Tensaw settlement and went over the Alabama by the Cut-off, to the west side of the Tombigbee, through a cane brake or swamp, seven miles and found a thick settlement."

No canebrakes show up on the plat maps for the northern half of Alabama, and only a few historical sources describe them. One is the diary of Richard Breckenridge (1816, in Halbert, 1898-1899), which details a solo trip through northwestern Alabama after leaving from Columbus, Mississippi. The exact path of the trip is difficult to determine (Halbert, 1898-1899), but Breckenridge observed canebrakes in what is likely Marion County: "I have seen no good land since morning, except in the creek bottom, where I had to cut my way with my tomahawk through a cane brake. I continued down the branch to a creek where I had to cut my way through another cane brake, in doing which I narrowly escaped being bit by a large rattlesnake."

Captain Edmund Pendleton Gaines (1807-1808, in Stone, 1971b) led a surveying party from Muscle Shoals on the Tennessee River to Cotton Gin Port on the Tombigbee, in what is now Monroe County, Mississippi. In the surveying notes, cane or canebrakes are mentioned 16 times, all in association with streams or rivers. None of these instances include detailed descriptions of the size of the canebrakes in Alabama, though several of them suggest that the canebrakes were relatively narrow and confined to the immediate vicinity of the creeks. For example, he wrote: "Thin Cane-brake, near a branch [of a stream], to the left"; "Narrow Cane-brake to the right"; "[A] narrow skirt of Cane-brake both sides [of a creek]."

CONCLUSION

The historical evidence suggests that canebrakes were common and extensive in Alabama in the 19th century. The greatest density appears to have been along rivers in the Black Belt and in the southwestern part of the state. Most of the data from the plat maps and the historical descriptions suggest that large canebrakes were associated with streams or rivers, apparently growing best in alluvial soils along river terraces. The absence of historical descriptions of canebrakes from the northeastern and southeastern corners of the state does not necessarily mean that canebrakes did not occur in these regions. Historical descriptions of vegetation for these portions of the state are more difficult to locate, likely reflecting travel and settlement patterns. Nevertheless, it does seem likely that canebrakes were much more common in the coastal plain, where meandering rivers provided broader alluvial terraces for their growth.

ACKNOWLEDGEMENTS

We would like to thank the librarians of the Alabama Department of Archives and History for their assistance and the Biology Department and the Environmental Science Program of Columbus State University for their support. David Whetstone, Michael Woods, and one anonymous reviewer provided many helpful comments on an earlier version of the manuscript.

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TORUS-BEARING PIT MEMBRANES IN SELECTED SPECIES OF THE OLEACEAE

Roland R. Dute[1,3], Steven Jansen[2], Charles Holloway[1] and Kyle Paris[1]

[1]Department of Biological Sciences, Auburn University
101 Life Sciences Building, Auburn, AL 36849, U.S.A.
[2]Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3DS, United Kingdom

[3]Correspondence: Roland Dute (duterol@auburn.edu)

ABSTRACT

Torus-bearing pit membranes allow water conduction between wood cells, but at the same time inhibit passage of air embolisms. These structures are common in *Ginkgo* and conifer woods but rare in eudicot woods. The genus *Osmanthus* of the Olive Family is one of the few eudicots whose wood possesses tori. In this study, wood from genera related to *Osmanthus* was investigated for the presence of torus-bearing pit membranes. Only the two species of *Picconia*, *P. excelsa* and *P. azorica*, had these structures. Species of *Nestegis*, *Notelaea*, and *Phillyrea* did not. The structure, chemistry, and function of tori in *P. excelsa* and *Osmanthus* species seem identical. Further studies are needed to clarify whether the torus has evolved multiple times in the Olive Family, or whether it represents a shared, primitive structure.

INTRODUCTION

Bordered pit pairs connect water-conducting cells of plants. The anatomy of these structures is described in detail in Dute *et al.* (2001, 2004). In short, a porous pit membrane is "flanked on either side by a pit border containing an opening or aperture that provides access to an adjoining cell lumen" (Dute *et al.*, 2004). The pit membranes provide passage for water molecules but at the same time are able to prevent air bubbles (embolisms) from spreading. One mechanism by which these competing functions occur involves a pit membrane in which a porous margo region surrounds a thickened, impermeable torus. In the presence of an air bubble, the pit membrane is displaced from the air-filled cell and occludes the aperture leading to the neighboring intact, water-conducting cell (Zimmermann, 1983; Hacke *et al.*, 2004). Tori are common in the intervascular pit membranes of conifers (Bauch et al, 1972) and *Ginkgo* (Dute, 1994), but at one time were thought to be absent from the wood of dicotyledonous angiosperms.

Tori in intervascular pit membranes of eudicots were first observed by Ohtani and Ishida in 1976. Among specimens investigated by those authors were three species of *Osmanthus* (*O. fragrans*, *O. heterophyllus*, and *O. fortunei*) from the Oleaceae. Subsequently, Dute

and Rushing (1987, 1988) observed tori in *Osmanthus americanus*, the only American species within the genus. This list was extended by Rabaey et al. (2006) who noted tori in *O. serratulus* and *O. suavis*.

The Olive Family (Oleaceae) contains about 24 genera with 615 species (Stevens, 2007). Patel (1978) indicated that *Osmanthus, Phillyrea, Notelaea,* and *Nestegis* have similar wood anatomy. Recent work by Wallander and Albert (2000) using chloroplast DNA showed that these four genera, along with *Picconia*, were related. For these reasons, the possibility exists that tori might not be restricted to *Osmanthus* but might also exist in the aforementioned related genera. The present manuscript presents the results of a search for tori in wood specimens from species of *Phillyrea, Notelaea, Nestegis,* and *Picconia*.

MATERIALS AND METHODS

The specimens used in this study were received from the Royal Botanic Gardens Kew, Surrey, United Kingdom, and from the Leiden branch of the National Herbarium of the Netherlands (L) and are listed in Table 1. With two exceptions, the specimens represent branch pieces of 2-5 mm diameter. Two specimens (*Picconia excelsa* collected by Schweingruber [35] and *Notelaea excelsa* also collected by Schweingruber [19]) represent sections of larger branches or trunks with diameters of 62 mm and 52mm, respectively. Specimens were prepared for scanning electron microscopy (SEM), transmission electron microscopy (TEM), or light microscopy. For SEM, branch pieces were split longitudinally to expose either radial or tangential surfaces. Specimens were then attached to aluminum stubs with carbon-impregnated double-stick tape and sputter-coated with gold-palladium vapor. Observations were made with a Zeiss 940 DSM operated at 15 kV or with a Zeiss EVO 50 operated at 20 kV.

For light microscopy, material was hand sectioned transversely with a razor blade. The resulting slivers were placed in 95% ethanol and put under vacuum for two hours. Afterward, the specimens were infiltrated and finally embedded in JB-4 plastic over a two-day period. Transverse sections of 1-4 μm were cut with a glass knife on a Sorvall MT-2b ultramicrotome, affixed to glass slides and stained with benzoate-buffered, aqueous toluidine blue O. Photographs were taken with a Nikon D70 digital camera attached to a Nikon Biophot microscope.

Wood specimens of *Picconia excelsa* were prepared and viewed for transmission electron microscopy according to the method of Dute *et al.* (1990). Wood segments from herbarium specimens were placed in three changes of acetone over a two-hour period followed by embedment in Spurr's resin (Spurr, 1969). Embedded wood specimens were sectioned on an MT-2b ultramicrotome at an approximate thickness of 80 nm and deposited on nickel grids. Sectioned material was stained for either 2 or 20 minutes with 1% $KMnO_4$ in 1% sodium citrate (Donaldson, 2002) and viewed with a Zeiss EM 10 transmission microscope using an accelerating voltage of 60 kV. Some material was left unstained and viewed in that condition.

An investigation of the labels accompanying the herbarium specimens indicates that two samples of *Picconia* might be misidentified. Originally *Picconia* was included within *Notelaea* but was separated by DeCandolle in 1844. There are two species of this genus: *P. excelsa* DC and *P. azorica* (Tutin) Knobl. Both species grow in Macaronesia. According to a number of authors (Humphries,1979; Gomes, 1998; Arteaga *et al.*, 2006), *P. excelsa* is restricted to the Canary Islands and Madeira, whereas *P. azorica* is found only in the Azores. The specimen labeled *Notelaea excelsa* from Madeira is actually *Picconia excelsa* as *Notelaea* is not native to Madeira or any of the Macaronesian Islands (Sunding, 1979). Also, the specimen listed as *Picconia excelsa* (Ph118, Leiden branch of the National Herbarium of the Netherlands) was collected from Pico Island in the Azores and must certainly be *P. azorica*.

Table 1. Sources of wood specimens examined in this study.

Taxon	Herbarium	Date of Collection	Collector(s) No.
Nestegis			
N. sp.	L	8 Apr 1962	Melville 6867
N. apetala (Vahl) L. Johnson	L	10 Feb 19?83	Balgooy 4397
N. cunninghamii (Hook. F.) L. Johnson	L	16 Mar 1962	Melville 6736
N. cunninghamii	L	Mar 1909	Travers s.n.
N. lanceolata (Hook. F.) L. Johnson	L	6 Dec 1977	Orchard 4991
N. lanceolata	L	14 Feb 1979	Gardner 2313
N. montana (Hook. F.) L. Johnson	L	19 Aug 1974	Wright 662
N. sandwicensis (Gray) Knobl.	L	23 Sep 1975	Herbst 5472
N. sandwicensis	L	28 Dec 1933	St. John 13833
N. sandwicensis	L	22 Jun 1985	Heller 2415
N. sandwicensis	L	23 Oct 1932	Swezey s.n.
N. sandwicensis	L	9 Feb 1930	St. John 10283
N. sandwicensis	L	21 Dec 1947	St. John 22887
N. sandwicensis	L	1 Jun 19?82	Balgooy 4253
N. sandwicensis	L	26 Mar 1972	Spence 38
Picconia			
P. azorica (Tutin) Knobl.	Kew	1894	Trelease 5129
P. excelsa (Ait.) DC	L	14 Feb 1923	Cool 529
P. excelsa	L	Mar 1906	Pitard 655
P. excelsa	L	Jun 6 1981	Cancap Ph 118
P. excelsa	L	13 Mar 1987	Schweingruber 35
Notelaea			
N. sp	L	25 Feb 1973	Craven 2403
N. sp	L	25 Aug 19?72	Webb s.n.
N. excelsa Webb & Bert.	L	10 Mar 1982	Schweingruber 19
N. francii Guillaumin	L	17 Jan 1968	Schodde 5266
N. johnsonii P.S. Green	L	30 Sep 19?89	N. Gibson 1118
N. ligustrina Vent.	L	9 Dec 1973	Steenis 23432

N. ligustrina	L	7 Feb 1960	R. Carolin 26894
N. linearis Benth.	L	15 Sep 1977	Haegi 1404
N. lloydii Guymer	L	18 Jul 1985	Self AQ 433720
N. longifolia Vent.	L	27 Oct 1981	Kanis 2103
N. longifolia	L	22 Nov 1966	Pullen 4203
N. longifolia	L	s.d.	Mueller s.n.
N. longifolia f. glabra	L	6 Aug 197?	Durrington 755
N. longifolia f. longifolia	L	11 Oct 1966	Schodde 5094
N. microcarpa R.Br.	L	11 Aug 1964	Adam 1261
N. microcarpa	L	25 Oct 1947	Smith 3552
N. microcarpa var. microcarpa	L	21 Aug 1969	Dunlop 609
N. microcarpa var. *velutina*	L	25 Jul 1969	Clark 1726
N. neglecta P.S. Green	L	Oct 1905	Maiden NSW 33631
N. ovata R.Br.	L	24 Aug 19?30	Hubbard 3757
N. punctata R. Br.	L	24 Feb 1973	Adams 3066
N. venosa F. Muell.	L	8 Nov 1977	Coveny 9726

Phillyrea			
P. latifolia L.	Kew		Campbell s.n.
			Accession Numbers
P. latifolia	Kew[4]		12872
P. media L.	Kew[4]		12873
P. media	Kew[4]		12874

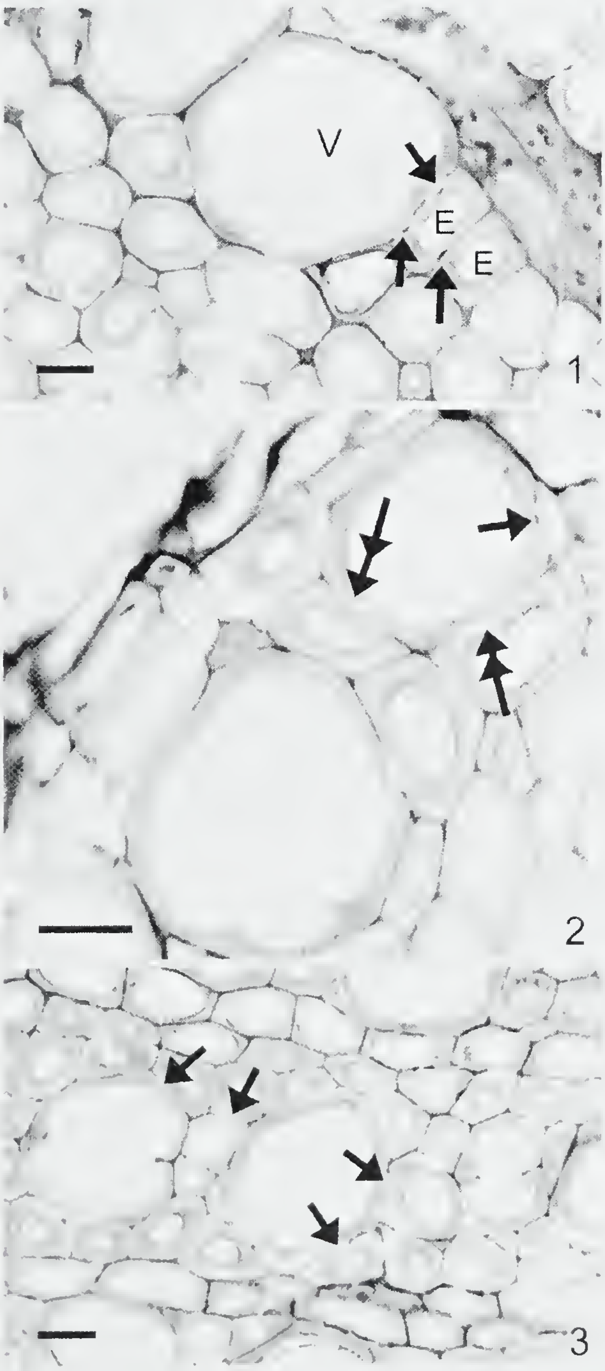
[4]Specimens taken from the wood collection in the Economic Botany Department

RESULTS

Of the four genera investigated in this study, only the *Picconia* species were observed to possess tori. "*Picconia* species" in this instance includes the specimen labeled *Notelaea excelsa* (Table 1). *P. excelsa* and *P. azorica*, therefore, represent new additions to the list of torus-containing eudicot species. Tori in *P. excelsa* are common (Fig.1), but tori are rare and difficult to locate in the *P. azorica* specimen from Kew (Fig. 2). The specimen listed as *Picconia excelsa* (Ph 118, Leiden branch of the National Herbarium of the Netherlands) (but in reality *P. azorica*) had wood with numerous tori. All other investigated species of *Notelaea, Nestegia*, and *Phillyrea* lacked a torus (Fig. 3).

As viewed with the light microscope, the torus of *P. excelsa* appears more or less spindle-shaped in transverse section (Fig. 1). Frequently, the pit membrane is aspirated and the torus blocks one of the apertures of a given bordered pit pair (compare Figs. 1 & 4 *vs* Fig. 5). This situation is to be expected in air-dried wood.

Tori exist between conducting elements of both early and late wood. The conducting elements in the wood of *P. excelsa* consist of vessel members and tracheids (Baas *et al.*, 1988). However, it can be difficult to distinguish between narrow diameter vessel members and tracheids. These two cell types are herein referred to as narrow tracheary elements to distinguish them from the larger diameter vessel members. In *P. excelsa* wood, tori are found between vessel members and narrow tracheary elements, between narrow tracheary elements (Fig.1), and between vessel members.



Key to labeling: A = aperture in pit border; E = narrow tracheary element; L = cell lumen; M = margo of pit membrane; T = torus; V = vessel member.

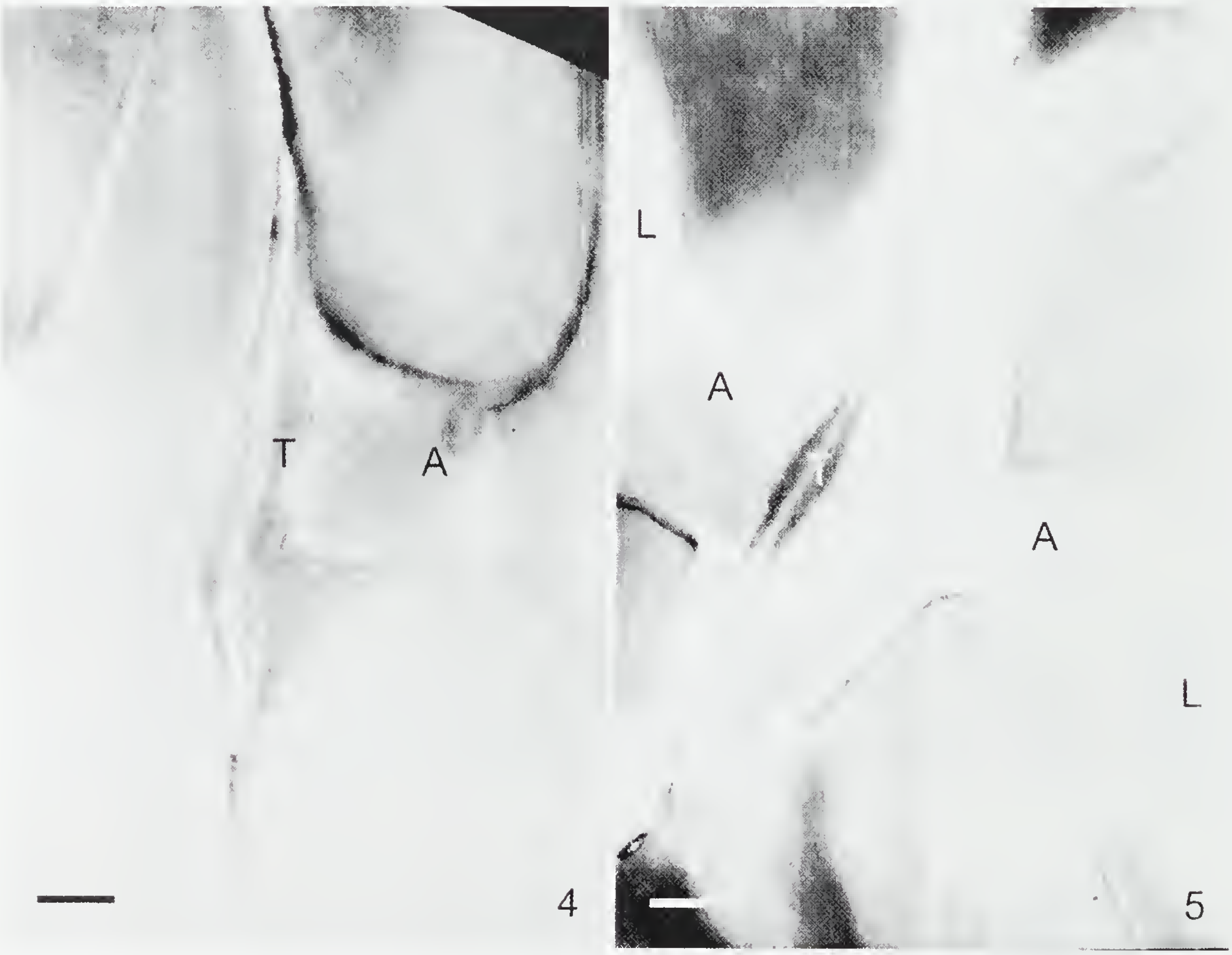
Figure 1. Transection of wood from *P. excelsa* showing tori (arrows) between a vessel member and narrow tracheary elements. Scale bar = 25 µm.

Figure 2. Transection of wood from *P. azorica*. The single arrow indicates a torus between a vessel member and a narrow tracheary element. The double arrows show bordered pit pairs without a torus. Scale bar = 25 µm.

Figure 3. Transection of wood from *Notelaea linearis*. Tori are not present in the bordered pit pairs (arrows) between water conducting cells. Scale bar = 25 µm.

Close inspection with TEM of $KMnO_4$-stained material shows the torus to consist of an electron-lucent layer sandwiched between two electron-dense pads (Figs. 4, 5). The margo portion of the air-dried pit membrane is collapsed and difficult to visualize even with TEM.

Further information regarding tori can be gained by observing pit membranes of *P. excelsa* in face view using SEM. Torus location on and structure of the pit membrane appear identical in *Picconia excelsa* and *O. americanus* (compare Fig. 6 in this manuscript with Fig. 1 in Dute & Rushing, 1987). The circular torus thickening is centrally located on each pit membrane (Fig. 6). The torus does not have a fibrillar appearance in contrast to the surrounding margo (Fig. 7). The mean horizontal diameter of the torus is 3.08 μm (range = 2.11--3.52 μm, N = 15).



Figures 4, 5. Transmission electron micrographs of aspirated (Fig. 4) and nonaspirated (Fig. 5) pit membranes with tori in wood of *P. excelsa*. Scale bars = 0.25 μm (Fig. 4) and 0.5 μm (Fig.5).

Fortuitous views in which a pit membrane is partially removed show clearly the type of pit aperture associated with torus-bearing pit membranes (Fig. 6). Also, the outline of the subtending aperture frequently can be seen in the aspirated torus. Such evidence indicates that the apertures vary from circular to elliptical and are smaller in diameter than their associated tori (Fig. 6).

The intervascular pit membranes of species of the other three genera lack tori. The bordered pit pairs often appear empty (without a partitioning membrane) in cross-sections viewed with the light microscope (Fig 3). In herbarium specimens, the pit membrane collapses into a thin line that is hard to visualize with the light microscope. Also, the pit membrane is frequently pressed against the pit border (aspirated) and thus difficult to distinguish. However, the pit membranes are clearly visible in face view in both radial and tangential longitudinal sections observed using SEM (Fig. 8). The entire surface of such membranes is fibrillar. Often the pit membranes are aspirated and torn over the site of the subtending aperture (Fig. 8).

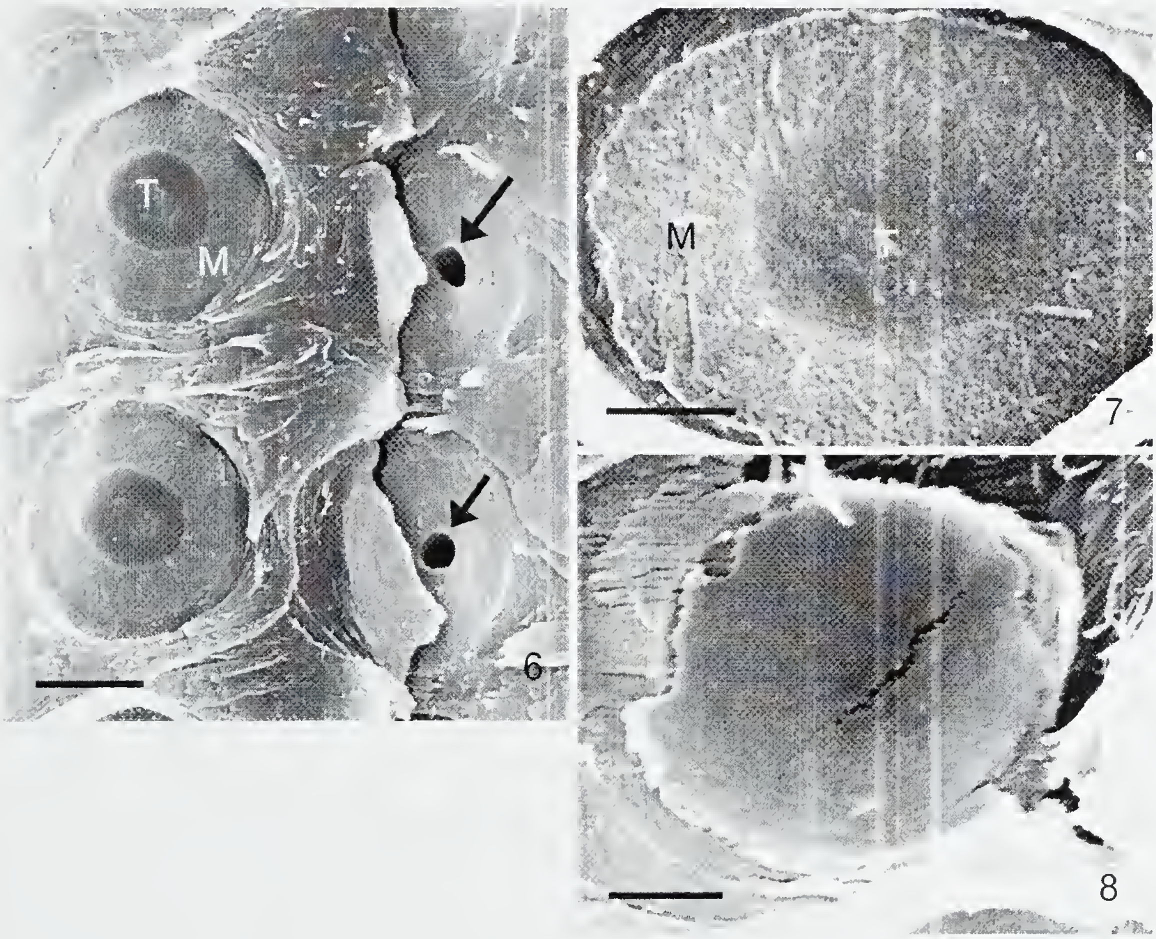


Figure 6. Scanning electron micrograph of longitudinal section of wood of *P. excelsa*. Pit membranes are observed in surface view. The two membranes on the left are intact; the two membranes on the right have been partially removed to expose the subtending apertures (arrows). Scale bar = 2.75 μm.

Figure 7. A detailed view of a pit membrane from *P. excelsa* (SEM). Note the difference in texture between torus and margo. Scale bar = 1.0 μm.

Figure 8. A scanning electron micrograph of a pit membrane (in surface view) from the wood of *Nestegis sandwicensis*. No torus is present. Scale bar = 1.0 μm.

DISCUSSION

Systematics

In the past, confusion existed at the generic level within the Tribe Oleeae, with some species having, at one time or another, been classified in *Nestegis*, *Notelaea*, or *Osmanthus* (Green, 1963). Wood anatomy confirms the close relationship among *Phillyrea*, *Notelaea*, *Nestegis*, and *Osmanthus* (including *O. americanus*) (q.v. discussion in Patel, 1978). All four genera possess an oblique vessel pattern as well as spiral thickenings in vessel members and tracheids. Baas *et al.*, (1988) observed similar anatomy in *Picconia* and two species of *Chionanthus*.

Small (1933) separated *Osmanthus americana* (sic) from the remainder of the genus as *Amarolea americana* based on coralloid inflorescences, subsessile flowers, introse anthers, and capitate stigma. In addition, *O. americanus* is hexaploid relative to other species of *Osmanthus* investigated for chromosome numbers (Taylor, 1945). In his review of Oleaceae, Johnson (1957) also commented on *O. americanus* being distinct from other *Osmanthus* species. Cladistic analyses of DNA sequences from two chloroplast loci confirm the close relationship among *Osmanthus* (*sans O. americanus*), *Phillyrea*, *Picconia*, *Nestegis*, and *Notelaea* (Wallander & Albert 2000). *O. americanus*, in contrast, seems to be more closely related to *Chionanthus* than to the aforementioned genera (Wallander and Albert, 2000). This being the case, the argument for *Amarolea americana* becomes more persuasive.

A generic hybrid between *Osmanthus* and *Phillyrea* has been described (q.v. discussions in Sax and Abbe, 1932 and Taylor, 1945). It would be interesting to investigate such a specimen for the presence of tori.

Johnson (1957) considered *Picconia* to be most closely related to *Phillyrea* according to both vegetative and floral characters. Phytogeography lends credence to this hypothesis as *Phillyrea* species are native to the Mediterranean and western Asia (Johnson, 1957). In contrast, *Notelaea* is restricted to eastern Australia (Johnson, 1957; Sunding, 1979). However, the geographic disjunction between *Picconia* and *Notelaea* might not be a significant problem as fossils of Macaronesian plants, including *Picconia excelsa*, have been found throughout southern and central Europe (Sunding, 1979).

Structure/Function

Removal of the thickenings (pads) in *Osamanthus americanus* using sodium chlorite led to rupture of the pit membrane at the site of the aperture when the membranes were subsequently dried (Dute and Rushing, 1987). The authors felt that the presence of torus thickenings would inhibit rupture of the aspirated pit membrane where it contacts the aperture and would inhibit spread of air embolisms. A similar explanation was put forth by Wheeler (1983) to explain the selective advantage of pit membranes with tori in species of *Ulmus* and *Celtis*. When comparing air-dried herbarium specimens of torus-bearing and non-torus bearing pit membranes of different species in this study (Fig. 7 *vs* Fig. 8), the efficacy of the torus in strengthening the pit membrane is evident.

Treatment of *P. excelsa* tori with $KMnO_4$ showed a stain distribution identical to that found in *O. americanus* by Coleman *et al.* (2004); that is, heavily stained torus pads *vs*

an unstained compound middle lamella. This result was interpreted in *Osmanthus* (in conjuction with the results of acriflavin staining) as indicating the presence of lignin in the torus. The $KMnO_4$ results in *P. excelsa* must be viewed with some caution as confirmatory experiments using other techniques have not been done. Nevertheless, the similarity in stain deposition between the two species is intriguing.

In *O. americanus* the torus pads appear late in ontogeny and are associated with a microtubule plexus (Dute and Rushing, 1988). Because of the close relationship of *Osmanthus* and *Picconia*, we would hypothesize the same to be true in *Picconia* spp. TEM studies of freshly preserved material are needed to confirm this hypothesis.

Note in added proof: While preparing this manuscript, the senior author was asked to review another manuscript submitted to the IAWA Journal and entitled, "Micromorphology and systematic distribution of pit membrane thickenings in Oleaceae: tori and pseudotori," by Rabaey *et al.* In this article the authors present evidence for tori in pit membranes of *Picconia excelsa* and *Chionanthus retusa.* They found no tori in *P. azorica.*

ACKNOWLEDGEMENTS

We wish to thank Mr. Curtis Hansen, curator of the John D. Freeman Herbarium at Auburn University (AUA), for his assistance in clarifying the taxonomic problems encountered in this study. Also, we wish to thank Dr. Pieter Baas for providing specimens.

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REMEDIATION OF LNAPL-CONTAMINATED SAND BY USING HUMIC ACID AS A SURFACTANT

David Steffy[1] and James Rayburn[2]
[1]Department of Physical and Earth Sciences, [2]Department of Biology, Jacksonville State University, 700 Pelham Rd. North, Jacksonville, AL 36265-1602

Correspondence: Steffy, David (dsteffy@jsu.edu)

ABSTRACT

Humic acid (HA) can be used as an anionic surfactant which promotes the mobilization of the petroleum, which is a low-density, non-aqueous phase liquid (LNAPL), in porous aquifer material. Short-column tests of a HA solution at the critical micelle concentration (CMC) improved the LNAPL removal efficiency up to about 81%. HA developmental toxicity was also tested using the Frog Embryo Teratogenesis Assay-*Xenopus* (FETAX) methods. The 96-h LC50 was approximately 3.0 mg/ml and the 96-h EC50 (malformation) was approximately 8.5 mg/ml. Although malformations were observed, no significant teratogenic effect is evident for HA in *Xenopus* embryos. Advantages of HA as a surfactant are that it is inexpensive, a naturally occurring substance, abundant, relatively low oxygen demand, and that it promotes the mobilization of LNAPL. Disadvantages of HA are that it is anionic, which results in the dispersion of clays that may lead to aquifer clogging of the pores, and that the HA has an LC50 in the vicinity of the CMC, which is the optimum concentration for using the HA as a surfactant. This indicates that the toxicity may be due to the disruption of cell membranes.

INTRODUCTION

Underground storage tanks commonly contain liquid fuels and chemicals, and many have leaked through the years. Prior to 1970, most underground storage tanks were made of steel, which tends to corrode in a wet subsurface environment (Fitts, 2002). Some of these liquids were immiscible organic compounds when released tend to form and distribute as a separate non-aqueous liquid phase in the subsurface porous medium. These released liquids or LNAPLs would partition themselves into the air, water, or soil phases based on their physiochemical characteristics. By partitioning, the LNAPL could impact an ever larger environment where humans, other fauna, and flora live.

Remediation of this contaminated subsurface could involve the recovery of the LNAPL by pumping the porous medium. It is well known that some of the organic liquid remains behind as a residual LNAPL during the pumping effort. To increase the efficiency of the recovery, surfactants are injected into the subsurface to mobilize the LNAPL and to make more available for extraction. This study will examine the use of a natural Humic acid

(HA) as a surfactant.

Residual LNAPL typically occupies 10-50% of the available pore space (Chatzis *et al.*, 1986). Commercial surfactants commonly remove up to 90% of the residual LNAPL in laboratory tests (Abdul *et al.*, 1990). Two mechanisms can be involved in this improved recovery – the surfactant can: (1) increase the LNAPL mobility, and (2) increase LNAPL solubility in water.

Humic acid is part of the humic substances that are extracted as a by-product from peat processing. The generation of humic substances is an inexpensive, large volume source that could provide a cost effective source of needed surfactant. Using a naturally occurring humic substance such as HA may eliminate unwanted environmental consequences of using a surfactant in the remediation of a contaminated soil. The use of HA as a surfactant is an untested technique in the remediation of contaminated soil.

A process has been developed for the production of low-cost HA from peat processing. HA appears to have proper surfactant capabilities and soil stabilization properties that could augment remediation of hydrocarbon contaminated sites (Steffy *et al.*, 2001). The testing and quantification of HA characteristics and applications in remediation are needed so that the potential of these surfactants can be evaluated.

Humic substances are nonvolatile, semi-polar polymers composed of a "chicken wire" pattern of aromatic carbon rings that are 10^{-3} to 10^{-6} mm (colloidal to molecular dimension) in length, with a molecular weight ranging up to 200,000 (Ghassemi and Christman, 1968). Surface activities of humic substances have been observed to be inversely related to the acidity of the humate and the pH of a humic aqueous solution (Chen and Schnitzer, 1978). Hence, some humic substances are readily soluble in dilute alkaline media (HA), but some are precipitated upon acidification (fulvic acids). Humic solutions are described as having anionic-surfactant characteristics and contributing to soil aggregation stability (Piccolo and Mbagwu, 1989). Tschapek and Wasowski (1976) found that the alkali-soluble fraction of humics are surface active; that is, they lower the surface tension of water, and appear to be dependent on ionic strength and on the extraction method of the HA. This dependency appears to be a function of the polydipsersive (heterogeneous) nature of the alkali-soluble fraction.

To date, HA has had only limited application as a remediation tool for contaminated soils (Bickerton, *et al.*, 2004). Bickerton *et al.* (2004) used a HA solution at a concentration of 3.66 mg/ml on petroleum-contaminated sands and silts in a controlled remediation effort. The results were inconclusive due to the lack of data. An earlier laboratory study by the same research group, found that HA solubilizes diesel contamination and also promotes the *in-situ* biodegradation process (Van Stempvoort *et al.*, 2002). These promising results warrant further investigation of HA and its use in remediating contaminated soils. Information that needs to be acquired includes: its dispersive capabilities, flocculation behavior, interfacial tensions, viscosities, saturation-pressure relationships, toxicity, and effects on the mobilization of residual contaminants.

There are problems associated with the use of surfactants, however. The following issues need to be addressed when using HA or any surfactant. Short-column tests of

surfactant application in a two-phase system (oil, surfactant) resulted in a non-uniform distribution of residual LNAPL after treatment (Ang and Abdul, 1991). Non-uniform distribution may result in channeling, which reduces the surfactant's effectiveness (Hornof and Morrow, 1987). Another concern is that certain surfactants hydrolyze to flocs which can combine and disperse soil colloids, which in turn could lead to aquifer clogging (Abdul *et al.*, 1990). Surfactants act at liquid-liquid interfaces, but also at solid-liquid interfaces, where they may adsorb to the solid (Rosen, 1989). Alternatively, they may precipitate under certain conditions (Stellner and Scamehorn, 1989; Jafvert and Heath, 1991). Both sorption and precipitation will reduce surfactant availability. Temperature reduction can reduce surfactant effectiveness, critically so below the Krafft point (West and Harwell, 1992). Surfactants can partition into the LNAPL if their solubility in LNAPL is high enough. They can also separate chromatographically.

Finally, surfactants must be acceptable environmentally. Laboratory studies reveal that recovery of LNAPL could be improved if HA were continuously pumped through the contaminated porous medium. Because of the large percentage of HA used, a toxicity/teratogencity test was used to determine the effects of HA. The bioassay test was carried out independently of the surfactant testing. The frog embryo teratogenesis assay-*Xenopus* (FETAX) was used to assess the developmental toxicity of HA. This assay has been used to evaluate the developmental toxicity of chemicals and mixtures for both human health and environmental health (Bantle *et al.* 1994; Rayburn *et al.* 1991).

Clearly, surfactant selection is a multifaceted issue (Vigon and Rubin, 1989), although guidelines for proper selection are readily available (Rosen, 1989; West and Harwell, 1992).

This study is directed towards characterizing the physical and chemical properties of HA developed from peat processing in terms of its surfactant capabilities and flocculent behavior. We also measured by laboratory column studies the effectiveness of utilizing HA as a surfactant in the remediation of hydrocarbon contaminated soil.. This study also investigated the dispersion of clays caused by the presence of increasing HA concentrations in the porous medium. Finally, we quantified the environmental acceptability of HA in terms of its toxicity.

MATERIALS AND METHODS

Humic Acid Extraction:

HA was derived from shredded, dry peat that was harvested in Bemidji County in northern Minnesota. Production of the HA from the peat for the laboratory tests was a simple batch process of acid/base extraction. For bioassay work HA, the pH was adjusted to approximately 8 with an addition of a sodium hydroxide solution. HA was stored at 4°C until use. HA concentration was determined by gravimetric analysis.

Critical Micelle Concentration Measurement:

The critical micelle concentration (CMC) is the concentration of the HA solution at

which the surface tension is the minimized (Lowe, 1999). Surface tensions of various HA solution concentrations were measured using a du-Nouy interfacial tensiometer (CSC Scientific Co., Fairfax, Virginia). A plot of HA concentration versus surface tension provides an estimate of the CMC.

LNAPL Recovery Tests:

Recovery of LNAPL was measured by a series of short-column tests. These test determined the relative performance of surfactant removal efficiencies. A contaminated soil with a known level of LNAPL saturation was flushed with a HA solution. The concentration of the solution was at the CMC . The efficiency of removal was measured by determing the amount of LNAPL that remained in the soil after flushing. Under the proper conditions, HA acts as a surfactant when flushed through unsaturated porous medium containing residual amounts of water and mineral oil. These tests followed the procedures of Ang and Abdul (1991) which provided guidelines for initial testing.

The laboratory tests were conducted with homogenous fine-grained sand, packed in a 54-cm borosilicate tube with a diameter of 3 cm (Table 1). The resulting packed column had sand bulk densities of ~ 1.00 g/cm^3 and porosities ranging from 21.5 to 24.7% (Table 1a). The LNAPL was a mineral oil dyed with Sudan IV (Sciencelab.com, Houston, Texas). The tests were initiated by establishing a water table condition in a vertical sand-packed column that becomes contaminated by the LNAPL.

Three glass columns packed with silica sand were initially saturated with water; the water was then allowed to gravity drain to establish the specific retention of the porous medium. Then 50 ml of mineral oil was allowed to infiltrate from the top while the bottom of the column freely drained into a graduated cylinder. After the mineral oil was drained, an initial level of residual saturation was measured ranging from 10.6 to 39.9%. The column was then rotated horizontally and pumped with the surfactant at a constant rate. The amount and rate of LNAPL displaced was measured. One hundred (100) ml of a 10% HA solution (3.4 mg/ml) was flushed through the column from top to bottom. The amount of mineral oil flushed (recovered) was measured.

Clay Dispersion Assay:

An assay of HA's ability to disperse clay in solution was evaluated. A disadvantage of using an anionic surfactant is that promotes clay dispersion, thus increasing the potential for aquifer clogging, and reduces the delivery of the surfactant to all areas of porous medium that contain residual LNAPL.

The procedure of this assessment was to fill a glass vial with approximately 5 grams of kaolinite, a non-swelling clay. The clay was mixed with de-ionized, distilled water for 2 hours, after which the mixture was allowed to settle for 2 hours. The turbidity was then measured using a HACH 2100P Turbidimeter (Hach Co., Loveland, Colorado). The procedure was done 7 times for each fluid tested. Various concentrations of HA were used. The turbidity versus HA concentration was then plotted to depict their relationship.

Teratogenesis Testing:

The Frog Embryo Teratogenesis Assay-*Xenopus* (FETAX) is a 96-h *in vitro* assay used to determine the developmental toxicity of compounds and mixtures (American Society for Testing and Materials, 1992). This assay uses embryos of the South African clawed frog, *Xenopus laevis*. This assay exposes to embryos from the small cell blastula stage to a free living larvae to chemicals and mixtures to determine potential developmental toxicity. Adult *Xenopus* were purchased from Xenopus I (Ann Arbor, MI) and kept in glass aquaria with recycled filtered water and kept on a 12 h:12 h light-dark cycle. They were fed high protein fish pellets with vitamins added. Adults were bred using human chronic gonadotrophin (Sigma, St. Louis, MO), injected in to their dorsal lymph sacs; 200 and 500 units for males and females respectively. Adults were placed in a false bottom breeding chamber as described by (McCallum and Rayburn, 2006). Embryos were collected the next morning and the jelly coat removed with 2% L cystiene (Sigma, St. Louis, MO). Embryos were double sorted and randomly placed into plastic Petri dishes (Fisher, Pittsburgh, PA). (60mm X 15mm) filled with control or test solutions. Three different experiments were performed with three different clutches of embryos.

The experimental unit was 20 embryos per plastic Petri dish (8 ml of solution; 2 replicates per dose; 4 control dishes) for each experiment. Three experiments were performed with 8 to 11 concentrations used for each experiment approximately 520 embryos were required for each test. A single HA extraction was prepared and used for all three experiments. The embryos were then placed in an incubator at 24°C with static renewal of solutions every 24 h. The test duration was 96 h. The dead embryos were removed and counted every 24 h.

At the end of 96 h, survivors were counted and scored for malformations, and lengths were measured. Statistical analysis began with a two way ANOVA using experiment as one factor, and dose as the second factor for length comparsions, followed by Bonferroni t-test multiple comparisons

ToxTools, a software for dose-response modeling, benchmark dose estimation and risk assessment was used to calculate LC50 (lethal concentration to induce 50% mortality) and EC50 (effective concentration to induce 50% malformation) with standard errors (ToxTools, 2001). ToxTools was chosen because it has a Developmental Toxicity model that incorporates mortality, malformation and growth. ToxTools also analyzed all of the results together for each of the three experiments. The additive model was used for all calculations in this paper. Teratogenic index (TI) is calculated by dividing the 96h LC50/ 96 h EC50. A TI ratio of greater than 1.5 indicates an increase of teratogenic risk (ASTM, 1991). A Bonferroni t-test was used to determine significant differences from controls for embryo length comparisons.

RESULTS

Measurement of the CMC:

Systematic measurement of the interfacial surface tension as a function of the concentration of HA solution reveals a break in its linear relationship. Generally, as the

HA solution concentration increases, the interfacial tension decreases. A break in this relationship occurs at a concentration of 3.4 mg/ml (Fig. 1). The break provides an estimate of the CMC of the HA solution (Lowe *et al.*, 1999).

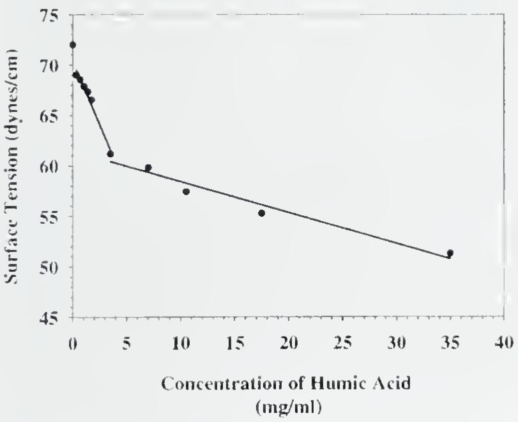


Figure 1. Determination of the critical micelle concentration for humic acid (~3.4 mg/ml or about 10% humic acid solution).

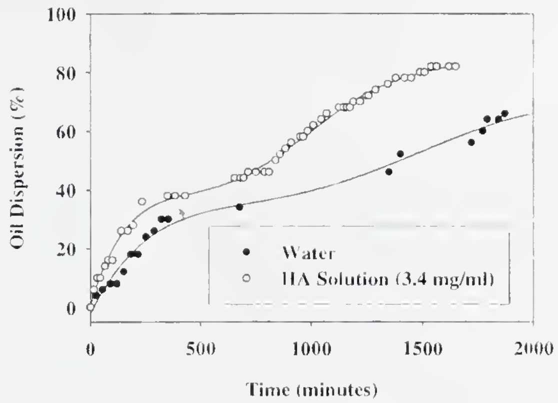


Figure 2. Comparison of oil displacement by a humic acid solution (surfactant) and by pure water.

Recovery of LNAPL:

HA was observed to quickly mobilize the residual oil by reducing the interfacial tensions of the water-oil system. Residual oil in unsaturated silicate sand with an approximate bulk density of 1.0 g/cm^3 ranged from 30 to 42% (Table 2).

Variations in both the residual water and oil saturations before flushing and the amount of recovered oil are probably due to uneven packing throughout the column which in turn could cause instabilities in fluid fronts and result in channeling.

Figure 2 depicts the overall effectiveness of pumping a HA solution to mobilize LNAPL in comparison to water. At equal pumping rates, the final amount of oil recovered is 81% for the HA solution and 60% for water. This represents a 35% improvement in oil recovery

Visual observations indicate that the HA solution mobilized the LNAPL (mineral oil) by decreasing the interfacial tension between the LNAPL and water phases. The change in interfacial tension is promoting the movement within the LNAPL continuum. Apparently, when the 10% HA solution was added to the column, the HA distributed itself as part of the water continuum rather than LNAPL changing its physical properties by dissolving the HA solution. Two tables 1 and 2 give the results of the recovery tests. Table 1 shows the basic characteristics of the columns used in the recovery assay. Table 2 shows the recovery of mineral oil with HA solution at 3.4 mg/ml. These results showed the proportion of mineral oil flushed was between 58% and 70% (Table 2).

Table 1. Physical characteristics of columns.

Test	Length of Column (cm)	Bulk Density (g/cm3)	Porosity (%)
1	52.0	1.00	21.5
2	52.3	1.02	24.5
3	53.1	1.00	24.7

Laboratory tests found that the pump rates showed no relationship to the amount of LNAPL recovered (displaced) (Fig. 3). However, in terms of pumping efficiency (amount of LNAPL recovered / amount of fluid pumped) – a low pump rate of 1.41 cm^3/min was the most efficient. HA at its critical micelle concentration of 3.4 mg/ml was then used to increase LNAPL mobilization. When the HA solution was used, recovery was increased from 60% to 81% (Fig. 2), and efficiency was improved by over 180%.

Table 2. Results of flushing tests.

Test	Pumping Rate (cm3/min)	Initial Water Volumetric Saturation (%)	Residual Oil (%)	Recovered Oil (%)	Efficiency (%/cm3/min)
1	3.55	21.5	42.0	58.0	16.3
2	2.13	24.3	30.0	70.0	32.9
3	1.41	24.7	40.0	60.0	42.6

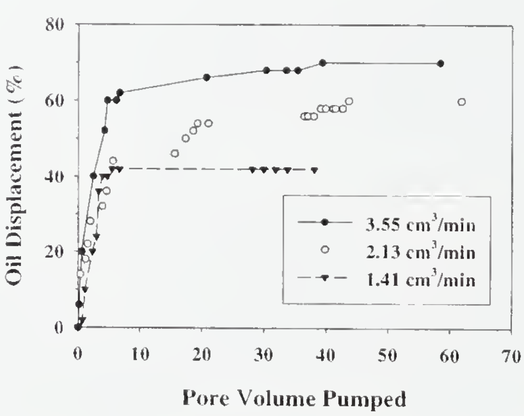


Figure 3. Effect of pumping rate on oil displacement.

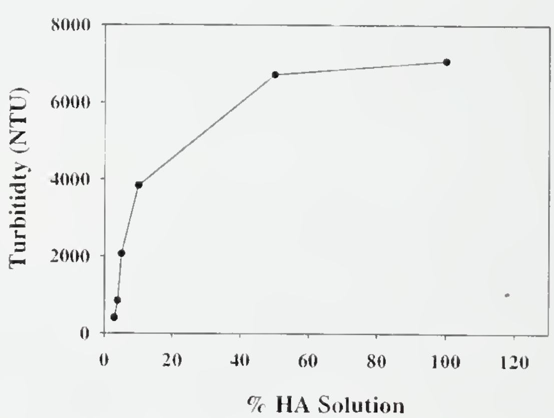


Figure 4. Clay dispersion as measured by turbidity caused by humic acid.

Clay Dispersion Assessment:

The HA acts as an anionic surfactant, and promotes the suspension of clay particles in solution. There is a rapid increase in the dispersive capability of the HA measured as turbidity up to a concentration of 10 % HA, after which the rate of increase in the dispersive capability drops of with increasing HA concentration (Fig. 4). This change in the dispersive capability of the HA solution occurs near the CMC concentration (3.4 mg/ml).

Results of Toxicity Testing:

A total of 1280 embryos were used for the three experiments. Of these, 240 were control embryos with ASTM acceptable control rate of 6.24% for mortality and 7.62% for malformation. The 96 h LC50 was 3.729 mg/ml (Table 3). The 96 h EC50 (malformation) was 6.499 (Table 3). The LC10 (to cause increase of risk of 10% mortality) was 1.440 mg/ml and an EC10 malformation of 2.060 mg/ml. The probability estimation curve for malformation (Fig. 5) indicates risk estimation reached 50% at the highest HA concentration used in this study. The average mean growth of control embryos over the 96 hr test duration was 9.45 mm (Fig. 6). There were only two concentrations with means significantly different from controls, 1 and 5 mg/ml (Fig. 6). Because means of the 2-4 mg/ml concentrations were not significantly the different than controls, result for 1 mg/ml is most likely an anomaly. Only the mean of the highest concentration differed significantly from the control, indicating that the chemical did not cause significant growth reduction at concentrations that do not affect mortality. Tox-tools estimated a maximum risk of <0.01 ($<1\%$) for the highest concentration of HA tested (data not shown). The Teratogenic Index (TI) is the 96h LC50/ 96h EC50 which is 0.574 (Table 3) which also indicates that HA is not a weak teratogen. Few malformations were seen except at extremely high concentrations (concentrations greater than the LC50 value). These malformations included muscular kinking of the tail, reduced head, and gut malformations typical of non-teratogenic compounds (Fig. 7).

Table 3. Ninety-six (96) h LC 10, 30, 50 and EC 10, 30, 50 values for HA

96 h Risk	Mortality (mg/ml)	Mortality SE	Malformation (mg/ml)	Malformation SE	Teratogenic Index* only for LC50 value
LC10	1.440	0.420	2.060	0.624	
LC30	2.748	0.444	4.506	1.393	
LC50	3.729	0.427	6.499	2.033	0.574

Teratogenic Index = 96 h LC50 / 96 h EC50.

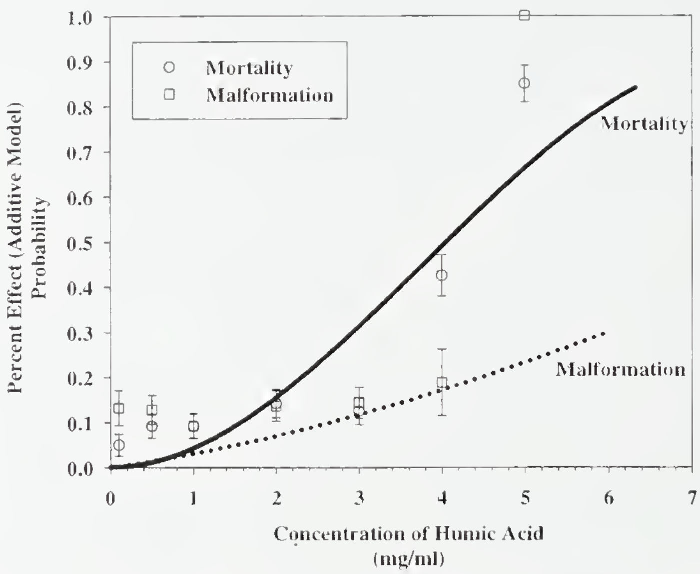
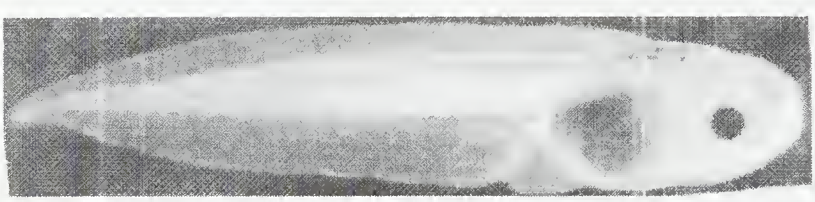


Figure 5. The summary concentration-response graph of humic acid for all three experiments. Circles represent actual mortality with standard error for concentrations tested. Squares represent actual malformation with standard error for concentrations tested. The solid line and dotted lines represent mortality and malformation probability estimation from Tox-Tools respectively. Estimations are from the additive risk model.



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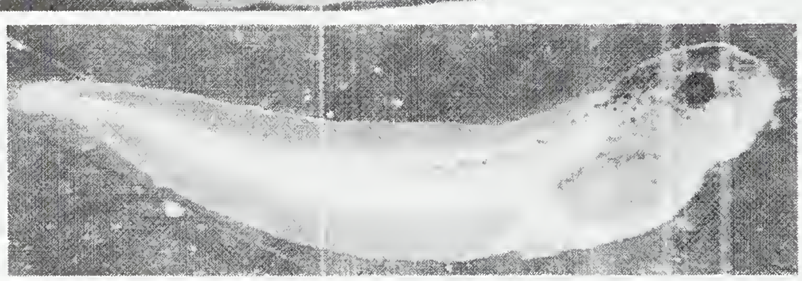

B

A **Figure 7. Side views of (A) a control and (B) a humic acid (5 mg/ml) treated embryos.**

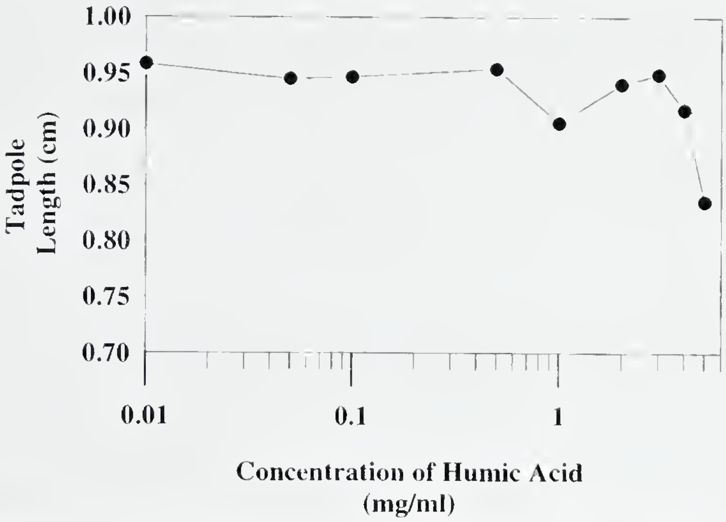

Figure 6. The overall growth graph for humic acid. The * represents significant difference from controls by Bonferroni t-test. Error bars are standard errors.

DISCUSSION

Laboratory studies show HA to have potential utility as a surfactant for use in the displacement of LNAPL in sand aquifers. At concentrations of ≥3.4 mg/ml, a critical HA micelle concentration occurs, disrupting the interfacial tension between the air-HA solution. When a HA solution at this concentration is delivered to the water phase of an LNAPL-contaminated sand, the interfacial tension is quickly reduced, allowing the movement of residual LNAPL globules to occur. Laboratory-scale pumping tests demonstrated that LNAPL recovery increased from 60 to 81% with addition of HA, a 35% improvement over water as the displacing fluid. The efficiency of this recovery also improved 180%. Therefore, the use of HA solution as a surfactant could improve the remediation effort both in terms of effectiveness and economics. Field-scale applications of HA in the remediation of hydrocarbon-contaminated sand aquifers have shown some promising results as well (Bickerton, *et al.*, 2004; Van Stempvoort, *et al.*, 2002). These studies indicate that recovery of LNAPL is enhanced by HA solubilizing the residual LNAPL globules; however, our visual observations found that the majority of the recovery was enhanced by the HA changing the interfacial tension between oil and water (HA solution).

HA and fulvic acid are part of the naturally occurring dissolved organic carbon (DOC) component in water, and collectively are called humic substances. DOC commonly occurs at concentrations < 0.05 mg/ml in surface water areas such as wetlands, and 0.002-0.015 mg/ml in rivers and lakes (Drever, 1997). The DOC diminishes in concentration to < 0.002 mg/ml in groundwater systems because of degradation (Fitts, 2002). HA accounts for ~5% of the DOC (Drever, 1997). Therefore, the CMC HA concentration of 3.4 mg/ml used in this study is ~7,000 higher than what is naturally occurring in water systems. As such, toxicity assessment of HA is warranted.

Overall HA did not indicate an increase in teratogenic risk. The FETAX bioassay showed that general cytotoxicity was observed with an LC50 of 3.73. It is interesting that the LC50 is very close to the CMC of 3.4 mg/ml. This would indicate that toxicity of HA may be due to surfactant changes of water induced by HA.

CONCLUSIONS

HA has many attributes that make it a promising surfactant to enhance the mobilization of trapped LNAPL in a sand aquifer. The CMC of HA occurs at a relatively low concentration of 3.4 mg/ml, although this is ~7,000 times higher than is found in natural water concentrations. Applying HA at its CMC concentration insures that optimal surfactant effectiveness is realized in the remediation process. When applied through the aqueous phase, the HA quickly mobilizes the NAPL by reducing the interfacial tension in the LNAPL-water system. Laboratory testing of fine-sand material indicates that a simple continuous flushing recovered up to 81% of LNAPL, and that the higher pumping rates produced faster and larger oil recovery rates. However, recovery efficiency was optimized at a low pumping rate. Other advantages of using HA as a surfactant in the remediation of a sand aquifer are that HA is easy and inexpensive to produce, and places low oxygen demand on the natural aquatic system.

A disadvantage of using HA as a surfactant is that it readily disperses clays that may promote pore clogging. Generally, the dispersive effect increases as the concentration of HA increases. In addition, the CMC concentration of HA is near the LC50 as determined by FETAX tests.

ACKNOWLEDGMENTS

The authors would like to thank the following JSU students for their work in data collection: Cody St. John, Melissa Bandy, and Daniel Grogan. The authors also would like to thank Jacksonville State University and the Faculty Development Grants that supported this research project.

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BIOGRAPHY
of
Ronald P. Kiene

A native of Brooklyn, New York, Dr. Ron Kiene earned a B.S. degree from Saint John's University (NY), where he also played baseball (as a pitcher). He completed the M.S. degree (1984) and Ph.D. degree (1986) from the Marine Sciences Research Center at SUNY, Stony Brook. He did post-doctoral work at the University of Miami and then spent five years on the faculty at the University of Georgia Marine Institute at Sapelo Island. He moved to Alabama in 1993 when he joined the faculties at the Department of Marine Sciences, University of South Alabama, and the Dauphin Island Sea Lab.

Ron teaches graduate courses in Chemical Oceanography, Sediment Biogeochemistry, Ocean Variability and Global Change, Marine Microbial Ecology, Marine Biogeochemical Processes and Seminar in Marine Science. He has served as a mentor to 12 graduate students (7 M.S. and 5 Ph.D.). He has participated in thirteen major oceanographic cruises (for a total of 263 sea days) to the Ross Sea (Antarctica) and elsewhere. Ron was honored by receiving the University of South Alabama Alumni Outstanding Scholar Award (2000) and the Sigma Xi Award for Excellence in Research (1985).

He is a frequent and popular speaker at many national and international meetings. He is listed as an author on 121 scientific presentations: USA, Canada, England, Spain, Denmark, The Netherlands, Germany, and Italy. Ron has pursued numerous professional collaborations with many scientists from around the world.

Ron is among the top researchers in the world who study the connections of the ocean with the atmosphere, including biogeochemical cycling in marine environments. He focuses on the role of microorganisms in the cycling of organic matter and important elements (such as sulfur, nitrogen and carbon). This innovative research is conducted in local waters in Mobile Bay and on oceanographic cruises all over the world. The applications of Kiene's research have advanced our understanding of microbial food webs, biogeochemical cycles, and how microorganisms in the ocean can affect atmospheric chemistry and ultimately global climate.

Kiene is a member of the American Society for Microbiology, the American Society for Limnology and Oceanography, and the American Geophysical Union. He has served or is serving on the editorial boards of *Marine Chemistry*, *Applied and Environmental Microbiology*, and *Marine Ecology-Progress Series*. Furthermore, he routinely contributes as a reviewer for numerous other journals and funding agencies. Along with his collaborators (over the past 12 years), Ron has received more than three million dollars in research grants from NSF, EPA and other agencies. He is listed as an author in 91 peer-reviewed publications in scientific journals and books. Along with his coauthors, he has published multiple times in both *Science* and *Nature*. Certainly, Ron Kiene has made significant contributions in the area of biogeochemical cycling and microbial ecology in marine ecosystems.

With his wife Julie and two sons Andrew and Dylan, Ron lives in Mobile, Alabama, where he actively contributes to local school activities (students and teachers). He greatly enjoys serving as a coach for his son's youth baseball team. When he is not working, he enjoys catching and cooking fish. Most of all, he enjoys traveling to Alaska with his family on summer vacations. You can learn more about him on his university web page: www.usouthal.edu/marinesciences/fac_kiene.html.

The Alabama Academy of Science congratulates Dr. Ron Kiene on his remarkable accomplishments and wishes him continuing success in all of his future endeavors.

MINUTES OF THE ALABAMA ACADEMY OF SCIENCE FALL EXECUTIVE COMMITTEE MEETING SAMFORD UNIVERSITY SATURDAY, NOVEMBER 3, 2007, 8:00 AM; Room 033, Sciencenter

Call to Order 8:19 AM

Attending meeting; Safaa Al-Hamdani, B.J. Bateman, George Cline, Mijitaba Hamissou, Richard Hutiburg, George Keller, Larry Krannich, Akshaya Kumar, Adriane Ludwick, Ken Marion, Mike Moeller, Mickie Powel, James Rayburn, Kenneth Roblee, Michelle Sidler, P.C. Sharma, Brain Toone, D.B. Thompson.

Review of Minutes from spring meeting.

Discussion Items not in written reports:

1. Treasurer brought the possibilities of increasing dues to keep up with costs. To be investigated and discussed at next meeting.
2. Constitution and by laws need to be revised for Junior Academy to meet needs. Henry Barwood, Cathrine Shields, and Ludwick will arrange with Cline and Bateman and will investigate.

Motions:

1. To nominate David Nelson to Board of Directors to fill Vacancy. Seconded and Approved..
2. The Editor is to provide to web master 1-3 issues to put on web temporally to investigate the interest in web base journal.. - Seconded and Approved.
3. Motion to change Mason Scholarship members that are appointed for 2 year term to 3 year term, and change in by-laws.
4. Motion to accept EBSCO contract for web documentation, seconded and approved

THE FOLLOWING WRITTEN REPORTS WERE REVIEWED

Agenda B Items:

1. **Board of Trustees,** Steve Watts – No Report

2. **President** – George Cline
   I've spent the time since the meeting on a number of projects. The biggest project has been to find members for committees (See attached). My efforts have been moderately productive. Some holes have been filled, some old holes

remain, and some new holes have been created. I have chosen to fill as many holes as possible, regardless of who's responsibility based upon the Constitution, We need to discuss this at the meeting.

I've asked David Nelson to fill the spot on the Board of Trustees that was vacated by the death of Ron Jenkins with David Nelson. This is a one year position. David has agreed, but we need to approve this move at the Fall meeting.

I have been working with JSU's administration about recruiting at the Junior Academy, and increasing JSU's efforts at recruiting Gorgas Scholars.

I have been meeting with the Treasurer, the Secretary, and the Editor to address issues as they arose.

3. **President –Elect** - Kenneth Roblee
   My primary activity so far has been in the planning of the symposium at our annual meeting. I brought up an idea as to the content of the symposium to George Cline; the idea was to create a symposium centered around computer/ information security (possibly just "computer-related issues"), because this is such an important issue for just about everybody, and there is much research done in this area, such as in cryptography. Then he wanted me to start checking around for possible speakers, which is what I have been doing since then. Although some people I contacted would not be available for the conference, at the moment, I have two "probables," (a mathematician and a computer scientist). Also, related to computer issues is online courses; I am looking at getting a representative from the course management system "Blackboard" to give a talk.

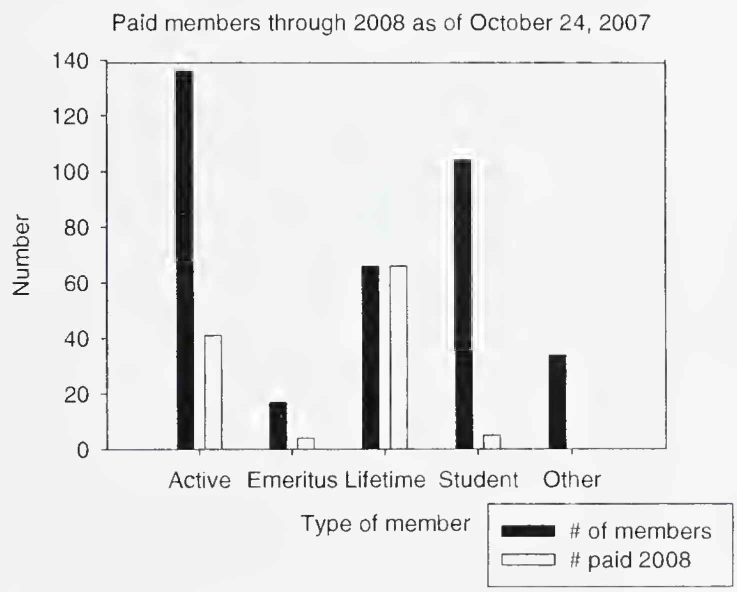
   Beyond getting this together, I attended the site visit at Samford University during the summer, where some of the logistics and facilities were discussed.

4. **Second Vice President** – Brian Thompson
   I have read through the constitution. I will be working with Ken Roblee and George Cline on nominations.

5. **Secretary** – James Rayburn
   1. I provided three sets of labels of current members to Safaa Al-Hamdani for the journal on May 21, 2007.
   2. I provided the minutes were to Dr. Al-Hamdani after email review on June 5, 2007.
   3. I emailed a copy of membership list as of August 8, 2007 to the executive committee.

4. As of October 24, 2007 we have 358 (of which 117 are paid for 2008) members including library and other members. Over the summer and fall we have taken in approximately $420 in dues (just turned in to treasurer). If membership stays stable we can expect $4,435.00 in dues. In 2006 membership dues were estimated at $5,290.00, and in 2007 we had an estimated $6,860.00 in dues paid.
5. On October 26 I sent out dues notice statements for 2008 to members not paid for 2008. This mailing included those not paid for 2007 but they are dropped from the rolls of AAS.
6. We currently have on the rolls 135 Active members (41 paid; 30.3%), 17 emeritus (4 paid), 67 lifetime, 104 Student (5 paid; 99 not paid), 35 other members (none paid; see figure below).
7. Memberships by section are listed below.

Section #	Total #
1	110
2	30
3	3
4	5
5	84
6	4
7	5
8	12
9	37
10	14
11	6
12	3
77(other)	34
None selected	11



8. The following are the current list that I have of paid and non-paid for 2008 AAS members for the executive committee members and officers only. Please check the list, if there are errors please let me know. Everyone on list b will or should have received a due statement. Individuals on list c may or may not as I do not have information for all of them.

a. The following Executive Committee members/officers are paid for 2008: George Cline, Steve Watts, Jim Rayburn, Houston Byrd, Marsha Griffin, Michelle Sidler, Larry Krannich, Larry Davenport, Mark Meade, Adrian Ludwick, Thane Wibbels, Roland Dute, Scott Brande, Prakash Sharma, Richard Hudiburg, Ellen Buckner.
b. The following Executive Committee members/officers are **not paid** for 2008: Kenneth Roblee, Brian Thompson, Taba Hamissou, Safaa Al-Hamdani, Harry Holstein, Eugene Omasta, Sergey Belyi, Mike Moeller.

c. The following Committee members/officers are **not paid** for 2007: BJ Bateman, Virginia Valardi, Jane Nall, Mickie Powell, Mark Puckett, Greg Gaston, Karen Utz, Cheryl Bullard, Melinda Lawson, Brain Toone, Henry Barwood, Marietta Cameron, Troy Best,.

6. **Treasurer** – Taba Hamissou

February 2007 – October 31st, 2007

Feb 21, 2007	
cd(1) + cd(2) +cd(3) + cd(4)	$56,560.38
Saving account	$1,259.80
Money Market	$2,837.58
Checking account (as of Feb. 21, 2007)	$10,012.60
October 31, 2007	
cd(1) + cd(2) +cd(3)	$27,371.63
Saving account	$1260.70
Money Market	$275.18
Checking account	$5,096.52
Total Assets all accounts (October 31, 2007)	$34,004.03

February 2007 – October 2007 Monthly Balances

Previous Balance (21-2-2007)	**$ 10,012.60**
Expenses entered 2/21/07 – 2/31/07	1,276.72
February 2007	
Income and other transactions	1,785.65
Expenses	462.00
Balance	10,059.53
March 2007	
Income and other transactions	215.00
Expenses	5,023.71
Balance	5,250.82
April 2007	
Income and other transactions	5,611.70
Expenses	2,505.01
Balance	8,357.05
May 2007	
Income and other transactions	5,742
Expenses	12,640.54
Balance	1,458.51
June 2007	
Income and other transactions	15,000
Expenses	1,641.00
Balance	14,817.51

July 2007	
Income and other transactions	200.00
Expenses	13,635.26
Balance	1,382.25
August 2007	
Income and other transactions	5,076.00
Expenses	505.00
Balance	5,953.25
September 2007	
Income and other transactions	4338.07
Expenses	9990.80
Balance	300.52
October 31, 2007	
Income and other transactions	6796.00
Expenses	2,000.00
Balance	5,096.52

7. **Journal Editor** – Safaa Al-Hamdani
   - Successfully released V. 78 Issue # 2-4
   - Journals established a uniform organization among all the manuscripts published.
   - Biography issue is slowly coming from the number, therefore, we have not included in every issue.
   - I would like to reexamine the responsibility of the people assisting in releasing the journal. Especially those in the editorial board and the archivist.
   - I would like to suggest that we establish a webpage for the journal to include: guidelines to the author, pdf files for recent issues, and other materials.
   - April issue remains to have a few problems in regards to some abstract do not appear in print. Some presenters complained about their abstracts not being included in the journal.
8. **Counselor to AJAS** – B.J. Bateman

   State Officers/Counselors Meeting

   The State Officers and the State Counselors met at Troy University to discuss the State Officer's roles for the upcoming year (2006-2007).

   Fall AAS Executive Meeting

   The State Counselor (B. J. Bateman) attended the Fall Executive Meeting of the Alabama Academy of Science.

Annual Meeting
The 2007 Annual Meeting, like all previous meetings of AJAS, was shared jointly with the Alabama Academy of Science. The host institution was Tuskegee University. Prakish Sharma was the local arrangements for the AJAS, B. J. Bateman, Counselor to the AJAS, and Wanda Phillips and Henry Barwood, Associate Counselors, planned registration procedures, space needs, and arrangements for the AJAS-JSHS banquet and other activities. Registration was held at the Kellogg Conference Center. Highlights of the program were:

(1) Paper Competition - The paper competition was conducted on Friday morning in L. H. Foster Hall with the finals Friday afternoon Clare Gamlin was chosen to be the overall winner and would therefore represent Alabama in national competition held at Huntsville, Al. The other four state winners (Ryan Dawson, Beth Clayton, Sarah Eiring, Grant Snyder) and Catherine Shields accompanied Clare to Huntsville.

(2) Banquet - More than One hundred students, teachers, university professors, and members of business, industry and government shared the Thursday night banquet.

(3) Business Meeting - The customary AJAS business meeting was held on Friday afternoon. This provided a time for announcing the overall winner, the outstanding region, the outstanding teacher(s), and other awards.

Winners and Awards 2007

Honorable Mention

Biological Sciences .... Abhi Haritha .... Altamont
Humanities.......................... Rebeca Daniels .... Brooks

"Best with the Least"

Biological Sciences .... Clare Gamlin .... JCIB
Engineering......................... R. T. Ayers .... Brooks
Humanities.......................... Rebeca Daniels .... Brooks
Mathematics .... Jessica Swinea .... Brooks
Physical Science .... Meredith Daniels .... Brooks

Second Place

Biological Sciences .... Hannah Black .... Brooks
Engineering......................... Brandon Kirkland .... JCIB

Humanities.......................... Nada Baalbaki .... Florence
Mathematics .... Charlotte Kent .... JCIB
Physical Science .... Linh Tranh .... JCIB

First Place
Biological Sciences .... Clare Gamlin .... JCIB
Engineering......................... Ryan Dawson.................... JCIB
Humanities.......................... Beth Clayton...................... JCIB
Mathematics .... Sarah Eiring...................... JCIB
Physical Science .... Grant Snyder..................... Altamont

Research Grant Award
Robert T. Ayers $35.00
Rebecca Daniels $100.00

AAAS Award .... William Brandon Kirkland
Jessica Swinea

Outstanding Teacher Award
Catherine Shields

Outstanding Region
Central

First overall	Clare Gamlin
Second overall	Beth Clayton
Third overall	Sarah Eiring

Newly elected officers for 2007-2008:

President	Brandon Kirkland	JCIB School
Vice-President	Nada Baalbaki	Florence High School
Treasurer	Jessica Swinea	Brooks High School
Secretary	Robert T Ayres	Brooks High School

JSHS Participants Attending the Annual Meeting
33 students, sponsors, and counselors attended the annual meeting as JSHS participants.

Students	
Chris Phare	Events Coordinator
Brandon Kirkland	JCIB
Clare Gamlin	JCIB
Ashley Getwan	JCIB

Brandon Kirkland	JCIB	
Ryan Dawson	JCIB	
Linn Trann	JCIB	
Beth Clayton	JCIB	
Charlotte Kent	JCIB	
Sarah Eiring	JCIB	
Abhi Haritha	The Altamont School	
Grant Snyder	The Altamont School	
Robert T Ayres	Brooks High School	
Hannah E Black,	Brooks High School	
Rebecca Daniels	Brooks High School	
Jessica Swinea	Brooks High School	
Nada Baalbaki	Florence High School	
Meredith Daniels	President	
Liz Rabalais	Secretary	
Marshall Everett	Shoals Christian School	
Omar Ahmed	Treasurer	
Brittney Bradford	Vice President	
Adults		
Billy Sanders	Assistant to the Counselor	
Gene Omasta	Assistant to the Counselor	
Wanda Phillips	Associate Counselor	
Henry Barwood	Associate Counselor	
B. J. Bateman	Counselor	
Linda Kanipe	Northwest Regional Counselor	
Vicki Farina	Brooks	
Catherine Shields	Central Region Counselor	
Jeanene Daniels	Brooks High School	Chaperones
Thomas Ayres	Brooks High School	Chaperones
Dina Baalbaki	Florence High School	Chaperones

9. **Science Fair Coordinator** – Virginia Valardi
This year seventeen student finalists, two student observers and their twenty - two accompanying adults traveled from six regional and one state science and engineering fair to Albuquerque, New Mexico on May 6-12 for the 2007 Intel/International Science and Engineering Fair. At this event, nearly 1,500 students from 47 countries competed for scholarships and prizes at the 58th Intel International Science and Engineering Fair.

Science Service, in partnership with the Intel Foundation, announced awards at the Intel ISEF 2007 Awards Ceremony. Student winners are ninth through twelfth graders who earned the right to compete by winning top prize at a

local, regional, state or national science fair. The International Science and Engineering Fair is sponsored by Intel and has been administered by Science Service since its inception in 1950. Science Service is a non-profit organization dedicated to advancing the understanding and appreciation of science among people of all ages.

2008 Intel/ISEF will be in Atlanta, Georgia May 11-16
<u>2007 winners from the Alabama Delegation were:</u>
Materials and Bioengineering - Presented by Intel Foundation
Intel will present Best of Category Winners with a $5,000 award and an Intel® Core™2 Duo processor laptop computer. Additionally, a $1,000 grant will be given to their school and the Intel ISEF Affiliated Fair they represent.
Second Award of $1,500
EN055 Carbon Fiber Makes a Pointe!
Harper-Grace Niedermeyer, 16, Catholic High School, Huntsville, Alabama

Electrical and Mechanical Engineering- Presented by Intel Foundation
Intel will present Best of Category Winners with a $5,000 award and Intel® Core™2 Duo processor laptop computer. Additionally, a $1,000 grant will be given to their school and the Intel ISEF Affiliated Fair they represent.
Fourth Award of $500
EE051 MEMS Accelerometer Pointing Device
Christopher Thomas Phare, 17, Jefferson County International Baccalaureate, Birmingham, Alabama

United States Coast Guard -- For projects that relate to boating and water safety.
First Award of $5,000
ET051 Effects of Renewable Gasoline Extenders on Fuel Line
Melissa Renee Snow, 17, Patrician Academy, Butler, Alabama

10. **Science Olympiad Coordinator** – Jane Nall

Possibly the best kept secret in the State, many volunteers of Alabama Science Olympiad provide students the opportunity to participate and compete in Science Olympiad. Teachers, parents, coaches, bus drivers, university professors, university work study students, and other volunteers work to provide the students of Alabama the joys of "doing science" in an arena resembling athletic tournaments.

Herculean efforts are made each year by staff and volunteers on several university campuses, and teachers, parents, and students of over 200 public and private schools, so they might experience the joys and thrills of doing lab hands-on science.

Presently, registration is in progress and tournament dates are being set. Director is working on incorporating Alabama Science Olympiad and seeking additional volunteers to serve on the Board of Directors. We are seeking additional campuses to sponsor tournaments. She is currently attending the SE Conference of Tournament and State Directors in Macon, Georgia and not able to attend this meeting.

Placing 10^{th} in the nation for membership, Alabama Science Olympiad continues to grow in numbers of teams and participation at all levels. For several years now, because of the number of teams registering in Alabama, two teams in both Division B (grades 6-9) and Division C (grades 9-12) have advanced to the national competition following successfully winning at regional and the state tournaments. Only the top ten states in membership receive the second invitation at the secondary level to compete at the national tournament. The elementary levels compete at various local and regional tournaments.

The University of West Alabama, Jacksonville High School and Auburn University host an A2 tournament (grades 4-6) and report they have a great time, and they are already planning this year's tournaments. There will be five regional C tournaments (University of Alabama - Tuscaloosa and Huntsville, Auburn University, Jacksonville State University and the University of South Alabama) and four regional B tournaments (University of Alabama - Tuscaloosa and Huntsville, Auburn University, University of South Alabama. We really need at least one more B host! State Alabama B will be held at Huntingdon College and Alabama C will be on the campus of Samford University in April.

Science Olympiad events address the National Standards for Science Education and comprise all areas of science including astronomy, meteorology, experimental design, genetics, anatomy, process skills for life science and biology, chemistry and polymers, physics, earth science and fossils, and water quality and the environment, map skills, GIS and remote sensing as well as building events such as a Rube Goldberg-like device, robot, bottle rocket, plane, bridge and tower building, musical instruments. Alternating events in taxonomy include topics of trees, amphibians and reptiles, birds, insects.

Director Nall is in search of more universities willing to host tournaments! Consider showcasing your campus and join us in the fun! The State Director is appointed by the Alabama Academy of Science. To date Alabama has been lead by two directors – 1985-1996 Mr. Steven Carey, University of Mobile and 1997-present Ms. Jane Nall, Spanish Fort High School and the University of Mobile.

National this year will be in our Nation's Capitol at George Washington University, May 30-31.

11. **Counselor to AAAS** – Steve Watts

The annual meeting for the AAAS affiliates will convene on February 14-18, 2007 in Boston, Mass. The general theme of this year's meeting is **Science and Technology from a Global Perspective.** This theme emphasizes the power of science and technology as well as education to assist less-developed segments of the world society, to improve partnerships among already-developed countries, and to spur knowledge-driven transformations across a host of fields. All state Academies maintain an association with the American Association for the Advancement of Science. We are members of the Section on Agriculture, Food and Renewable Resources and the Section on General Interest in Science and Engineering.

We welcome the opportunity for any AAS member to attend the AAAS meeting on our behalf. Information about the AAAS can be obtained at www.aaasmeeting.org.

12. **Section Officers**

I. **Biological Sciences** -- Mickie Powell

Although I was unable to attend the 2007 Alabama Academy of Science meeting at Tuskegee, Brian Burns has sent me his information on the meeting. The Biological Sciences section of the 2007 meeting went very well. There were about 184 participants (posters and papers) total and the Biological Sciences included about 34 papers and 29 posters. The facilities at Tuskegee were excellent

Brian Burns' two years as Section Chair are over and I (Mickie Powell, UAB) will be rotating up into the position. There has been some talk about trying to get more involvement from UA Biology. I will be contacting the Biology department at UA as well as other schools to encourage participation by both undergraduate and graduate students.

II. **Chemistry** – Houston Byrd – No report

III. **Earth Science** – Mark Puckett -- No report

IV. **Geography, Forestry, Conservation &Planning** – Greg Gaston

Six (6) people attended the Section IV session at the Spring 2007 Academy annual meeting. Half of the people in the room (two of my students and myself) were joined by one other professor (Dr. Izeagu), his student and a lone graduate student from Alabama all of which made up the balance of Section IV. All six people presented papers.

Section IV has a difficult time gaining a critical mass of participants to have a viable section meeting. Part of the problem is that the Academy annual meeting is held very close to the time of the AAG national meeting and most students are focused on that meeting. The universities in Alabama with geography, environmental management, and planning programs are UNA, UA, Samford, A&M, and JSU. These have all been contacted to participate, but participation is very low.

V. **Physics & Mathematics** – Brain Thompson
At the 84th annual meeting of the AAS, we saw presentation of 15 papers and 9 posters. Personally, I found all the presentations quite interesting.
At the business meeting, Akshaya Kumar of Tuskegee University was promoted to section chair, and Nirmol Podder of Troy University was elected section vice-chair.

VI. **Industry & Economics** – Marsha griffin – No Report

VII. **Science Education** – Karen Utz
The science education section plans to have a full complement of papers at the annual meeting on the Samford University campus in March 2008. Because of current commitments, Karen Utz's position as Chair of this section is going to be assumed by John Springer, Assistant Curator at Sloss Furnaces. John is extremely well-versed in industrial technology, as well as science education. He will be assisted by Karen and Lori Cormier, past section chair, in recruiting paper/poster submissions and assembling the 2008 program.

VIII. **Behavior & Social Sciences** – Vacant. – No report

IX. **Heath Sciences** – Melinda Lawson – No Report

X. **Engineering & Computer Science** – Brian Toone
While this has not been a particularly active year for this section, we do anticipate the upcoming activities:

1. Organization of the program for Section X at the 2008 annual meeting.
2. Selection of a vice-chair to replace Brian Toone, who is now chair.
3. Organizational meeting with the newly selected vice-chair.

XI. **Anthropology** – Harry Holstein – No Report

XII. **Bioethics & History/Philosophy of Science** – Michelle Sidler.
As the new Section Chair for XII: Bioethics and History/Philosophy of Science, my primary goal for this year is to learn the administrative process and increase participation for the section. To increase participation, I am compiling a list of previous section participants' contact information and soliciting proposals for AAS 08. In addition, I am contacting departments and colleges around Alabama who may have interested faculty to encourage their proposal submissions. At the AAS 08 meeting of Section XII, I plan to work with section participants to devise a list of goals for the next few years and to develop yearly themes that will provide a framework for submissions in the future.

13. **Executive Officer** – Larry Krannich
Since March, 2007, I have been involved in the following activities as the Executive Director of the Alabama Academy of Science:

1. Distributed the Local Arrangements Manual to the local arrangements committee at Samford to assist them concerning arrangements, program

booklet needs, and deadlines associated with the annual meeting of the Academy to be held on the Samford University campus, March 19-22, 2008.

2. Prepared and distributed letters in early October to Alabama colleges and universities to solicit financial support for the Journal.
3. Prepared the Call for Papers for the 85th meeting of the Academy that will be distributed to all Section Chairs in hard and electronic copy after November 15th.
4. Designed bookmarks advertising the Academy and participation in the annual meeting. These will be distributed statewide in late-November.
5. Requested from the American Chemical Society approval for co-sponsorship of the annual state-wide Undergraduate Chemistry Research Symposium.
6. Updated the fliers and letters being sent to all Alabama chemistry faculty to solicit the participation of undergraduates and Alabama college and university Chemistry faculty in the 4th annual Undergraduate Chemistry Research symposium to be held in conjunction with the annual meeting of the Academy.
7. Contacted local sections of the American Chemical Society in the State to assess their willingness to again co-sponsor the state-wide undergraduate chemistry research symposium with the Academy.
8. Consulted with Brian Toone, Editor for Electronic Media, to develop an on-line submission of Executive Committee reports and generate a compiled document for distribution at the meeting and to the Secretary.

Agenda Item C: Committee Reports

1. Local Arrangements – George Keller
On-Site Visit
Samford University, Birmingham, AL 35229
November 3, 2007

The local arrangements for the 85th Annual Meeting of the Academy were discussed with details included in the Appendix to these minutes. The registration fee structure will be the same as that used for the 84th annual meeting with the banquet fee set as $5 for pre-registrants. More than a sufficient number of rooms are available to host the various section meetings and wall boards in the hallways on all four floors of the Sciencenter will be used to accommodate the numerous poster sessions. All rooms are equipped with computers and ceiling mounted projection equipment, except for a couple of laboratories. The AJAS meetings will be held simultaneously with the AAS meetings in the Sciencenter. Because Samford University will be on Spring break, there

will be ample parking space. The Thursday night banquet will take place in the Samford Cafeteria located in the Ralph W. Beeson University Center. The availability of hotel space was discussed. All the information for the meeting will be posted on the web site in January 2008.

2. **Finance** – No Report
3. **Membership** – Mark Meade – No Report.
4. **Research** – Steve Watts

This year 12 students (down from 19 last year) applied for travel awards to the Tuskeegee University meeting. All were presenting papers or posters. All students were from out of town and were each awarded $35. Budgeted amount for travel is $750 and we encumbered $420. In addition, 6 students applied for research grants. The committee evaluated the grants and all of these were awarded in full ($1,500 of the budgeted amount of $2,400). Support for book purchases are no longer allowed this year, nor is travel to other conferences (decided at last fall meeting). Only 12 students (down from 23 last year and 40 the previous year) have applied for the Research Paper/Poster Competition in several sections. New (slightly modified) evaluation forms and suggested criteria were sent to all section chairs and are now on the web.

All categories of awards and activities were handled electronically for the fourth year. Several minor modifications may be needed for next year, but in general electronic submissions greatly improved the process and eliminated a gruesome paper trail.

We suggest that the paper/poster competition will be held on Thursday only, with the banquet on Thursday night where winners will be announced.

5. **Long-Range Planning – Adrian Ludwick** – No Report
6. **Auditing Senior Academy – Sergey Belyi** – No Report
7. **Aduiting, Junior Academy** – Govind Menon

July 2006- July 2007 Audit of Alabama Junior Academy of Science Financial Records

This is a report of the Alabama Junior Academy of Science Auditing Committee for the July 2006-July 2007 financial year. I have examined the books provided by the Alabama Junior Academy of Science Treasurer, Dr. B.J. Bateman. We are satisfied ourselves that the receipts and expenditures, as presented to us, are correct and that all expenditures are legitimate expenses.

The net worth as of June 30, 2007 is $11,855.47

8. **Editorial Board & Assciate Journal Editors** – Thane Wibbels – No report
9. **Place and Date of Meeting** – Mark Meade – No report
10. **Public Relations** – Roland Dute – No report
11. **Archives – Troy Best**

We need to obtain photographs (especially of members of the Executive Committee), committee reports, minutes of the AAS Executive Committee

meetings, and any other materials that may be of interest to our membership. Items that may not seem of interest at present may be of great interest in the future. Photographs of officers and members at meetings are of special interest.

If you have items that you believe may be worthy of inclusion in the AAS Archives, please send them to me or to Dr. Dwayne D. Cox, University Archivist, Auburn University Ralph B. Draughon Library, 231 Mell Street, Auburn University, AL 36849.

Access to our AAS Archives is available 7:45-4:45 Monday-Friday. Dr. Cox has provided the following information relative to access. Archives materials **do not** go out on Interlibrary loan. Patrons can come in and use them according to the donor specifications. Some require special permission from the donating office or persons who made the donation or sometimes the archivist. Materials to be used at night or weekends need to have special arrangements made so they can be pulled before 4:30 in the afternoon (Friday afternoon for weekend use). Copies can be made in most cases and that can be done either by going through InfoQuest or contacting Dr. Cox or the reference desk at 334/844-1732.

I encourage all officers and members of the AAS to donate significant documents, photographs, etc. to the archives.

12. **Science and Public Policy** – Scott Brande – No report
13. **Gardner Award** – Prakash Sharma

The first meeting of the Alabama Academy of Science was held at Sidney Lanier High School, Montgomery, Alabama, April 4, 1924, in conjunction with the Alabama Educational Association Meeting. Wright Gardner was elected as an office bearer of the academy in this meeting. Through his early studies he became determined to make teaching and research his two goals for his life. The Wright Gardner Award was established, after the name of this great future looking scientist and educator, by the Alabama Academy of Science in 1984 to honor individuals whose work during residence in Alabama had been outstanding. Persons nominated for this award have included researchers, teachers, industrialists, clinicians, scholars and active members and office bearers of the Alabama Academy of Science.

This is to request each and every member of this academy to publicize to individuals, heads of departments, deans and provosts of colleges and universities about this prestigious award. Please solicit nominations from individuals and different academic and industrial organizations for this award. The nomination should be forwarded to:

Dr. P. C. Sharma, Chair, Wright Gardner Award Committee,
Head of Physics Department

Tuskegee University
Tuskegee, AL 36088.
Phone: (334) 727-8998; Fax: (334) 724-3917
e-mail: pcsharma@tuskegee.edu

You are welcome to nominate by either e-mail or by mailing a hard copy.
The nominations should consist of the following documents.

(i) Formal Nomination Letter, (ii) vitae and at least three letters of references from
peers, administrators and one by an expert in area of his/her research, and
(iii) one page citation that will be used for presentation of the award.

Anything missing from items (i, ii, iii) will result in rejection of the nomination. The closing date for nominations is January 5, 2008. The award will be presented in the "Joint Annual Meeting of Junior and Senior Alabama Academy of Science Meeting, 2008.

14. **Carmicheal Award** – Richard Hudiburg
The committee looks forward to reviewing research articles published in Volume 78 of the *Journal of the Alabama Academy of Science* in 2007. The Emmett B. Carmichael Award will be announced during the 85th annual meeting in March 2008.
15. **Resolutions**—Mark Meade No report
16. **Nominating Committee – Brian Thompson**
I will be working with Ken Roblee and George Kline to identify nominations in time for the Spring 2008 meeting
17. **Mason Scholarship -- Mike Moeller**
Last spring the Committee reviewed four completed applications for the William H. Mason Scholarship. After assessing all application materials the Scholarship Committee offered the $1000 scholarship to Mr. Michael Hallman. Mr. Hallman accepted the award.

The previous recipients of the William H. Mason Scholarship are:

1990-1991	Amy Livengood Sumner
1991-1992	Leella Shook Holt
1992-1993	Joni Justice Shankles
1993-1994	Jeffrey Baumbach
1994 -1995	(Not awarded)
1995-1996	Laura W. Cochran
1996-1997	Tina Anne Beams
1997-1998	Carole Collins Clegg
1998-1999	Cynthia Ann Phillips

1999-2000	Ruth Borden
2000-2001	Karen Celestine, Amy Murphy
2001-2002	Jeannine Ott
2002-2003	(Not awarded)
2003-2004	Kanessa Miller
2004-2005	(Not awarded)
2005-2006	Mary Busbee, Bethany Knox
2006-2007	Kelly Harbin
2007-2008	Michael Hallman

Attached to this report is a copy of an announcement that the committee plans to be sending soon to deans in schools of science and education within Alabama. Members of the AAS Executive Committee are encouraged to copy and disseminate this information.

$1000 FELLOWSHIP IN SCIENCE TEACHING

FIFTH-YEAR PROGRAM

The non-traditional fifth-year program is designed to offer individuals possessing a bachelor's degree outside of education the opportunity to earn a master's degree in education with Class A certification. Further information, admission requirements and application procedures can be obtained from education departmental offices at Alabama colleges and universities offering the fifth-year program.

AWARDS

Recognizing the need for promoting superior science teaching at all levels, the Alabama Academy of Science has established an award to encourage scientifically trained students to enter the teaching profession. The William H. Mason Fellowship is $1000 for one year (non-renewable), and is tenable at any institution in the state of Alabama offering a teacher certification program. Awardees may choose to specialize in any area kindergarten through the 12th grade. Selection will be based on the extent to which the applicant shows promise for incorporating quality science instruction in his or her classroom.

ELIGIBILITY

Students who will have earned a B.S. or B.A. degree by the summer of 2008 are invited to apply for a William H. Mason Fellowship. Applicants must have the equivalent of a minor or major in a natural science, and must be applicants for a program leading to certification in teaching at any level K-12. Recipients will be required to teach in the state of Alabama for at least one year following the completion of the degree program for which the award is given.

PROCEDURES

A fellowship application form can be obtained from _______________
or by writing to:

Dr. Michael B. Moeller
Alabama Academy of Science
Box 5049 University of North Alabama
Florence, AL 35632

or by e-mail:or can be downloaded for the Academy's website:

mbmoeller@una.edu
http://www.alabamaacademyofscience.org

DEADLINE FOR RECEIPT OF APPLICATIONS IS FEB. 1, 2008

18. Gorgas Scholarship Program – Ellen Buckner

19. Electronic Media – Brian Toone.

We report the following activities:

1. Updated the main webpage for the AAS website and provided links to materials based on requests from the AAS president and Executive Director of AAS.
2. Complete the transmittal of the paper abstracts from the 84th annual meeting of AAS to the Editor of the *Journal of the Alabama Academy of Science*. This process was completed in a timely manner.
3. Provided preliminary information and links for the 85th annual meeting to be held at Samford University.
4. Responded to various requests from the President of AAS, Executive Director of AAS and other members concerning changes to the AAS website.
5. Developed uploading capability of reports for the Fall Executive Committee meeting to the AAS website.

Upcoming activities:

1. Updating and adding information for the 2008 annual meeting

2. Updating the electronic submission page for the annual meeting
3. Online membership application and online meeting registration (subject to discussion at executive meeting)

Agenda Item D – Old Business
None

Agenda Item E – New Business

1. EBSCO Licensing Agreement for JAAS:

Jeff Greaves, who is a Key Account Manager at EBSCO Publishing, contacted the Academy about wanting to include the Journal of the Alabama Academy of Science in the EBSCO Publishing databases that are sold to the library marketplace. In the Appendix to these minutes is a file that gives more detail about licensing (*Licensing with EBSCO Publishing*)and what it would mean for the journal. More information can be found at http://www.ebscohost.com/for_publishers. There are no costs associated with this licensing relationship. The only thing that is required is for us to provide them with the journal content. This could be by a subscription to the journal, sent to EBSCO Publishing. Also included in the Appendix is the standard non-exclusive *Licensing Agreement*. These were discussed and the Executive Committee agreed to enter into the EBSCO Licensing Agreement.

Agenda Item F – Adjournment
Adjourned 11:41 AM

Members of Alabama Academy of Sciences (2008)

Kassidy Alexander
Safaa Al-Hamdani
Muhammad Ali
Sherita Andrews
Robert A. Angus
Arthur G. Appel
David Arrington
Jacary Atkinson
Shaina Attoh
Rebecca Baggott
Mark and Karan Bailey
Basil Bakir
Laszlo Baksay
Ronald Balczon
Michael Barbour
Wayne T. Barger
John A. Barone
Amy Marie Barr
William J Barrett
John Barrett
Brittani Batts
Robert P Bauman
Janis Beaird
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Daley T. Beasley
John M Beaton
Lee R Beck
Peter Beiersdorfer
Sergey Belyi
Helen H. Benford
Troy L. Best
Kamala N. Bhat
Neil Billington
Benjie Blair
John Boncek
Larry R Boots
Wiliam R. Bowen
Coartney Boyd
James T. Bradley
Malcom Braid
Scott Brande
Andre Braxton
David C Brown
Lakisha Brown
Lisa Buchanan
LW Buckalew
Ellen Buckner
Charles E Bugg
Shuntele N. Burns
Brian S Burns
Laura Busenlehner
Gayle L. Bush
Houston Byrd
Malori Callender
Leslie Calloway
Steven Carey
Sherell Carey
Marcqueia L. Carson
Jan Case
Ashley Kay Casey
Gail H Cassell
Tanushree Chakravarty
Misty Chapman
Kristen Chappell
Melissa Charles
Kimberly Childs
Janese D. Christian
Cleary Clark
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George Cline
Andrew Coleman
Loretta A. Cormier
Megan Cox
Lonnie Craft IV
Thomas F Craig
Johnathan Crayton
Anne Cusic
J William Dapper
Larry Davenport
Cheryl G. Davis
Floyd Davis
Henry W. Davis
Richard Davis
WR Davis
Lewis S Dean
Tom Denton

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Austin Dixon
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Keela Dodd
Steve Donaldson
Lydia Dorgan
Tracy W. Duckworth
Julian L Dusi
Rosemary D Dusi
Roland R Dute
Hussain Elalaoui-Talibi
Geraldine M Emerson
Matthew English
Oskar M Essenwanger
Jenny Estes
Jeremy Evans
Whiney Evans
P. Taylor Ezell
Christine Feeley
Joe M Finkel
Sara Finley
Wayne H Finley
Sara Finley
Wayne H Finley
James H French
Michael Froning
Teshome Gabre
Edward B. Garner
Carolyn Gathright
Brittany Gay
Victoria K. Gibbs
Keith Gibson
Zachary Giffith
Kenneth R Gilbert
Fred Gilbert, MD
Cameron W. Gill
Leslie R. Goertzen
Narendra Kumar Govil
Lamesha D. Greene
Wendy Gregory
Marsha D Griffin
Jan Gryko
Robert T Gudauskas
Pryce "Pete" Haddix
James H Haggard
Rosine W Hall
Mijitaba Hamissou
Sig Harden
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Victor Harris
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Antonio Hayes
Leven S Hazlegrove
Qinghua He
Paul Andrew Helminger
Justin Hendricks
B Bart Henson
Donald Herbert
Miriam Helen Hill
Damian Hillman
Damon Hillman
Thandiwe Hlatywayo
Emily Holden
Richard D Holland
A Priscilla Holland
Dan C. Holliman
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Candice Howard-Shaughnessy
Xing Hu
Richard A Hudiburg
Kelli Hudson
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Ronald N. Hunsinger
Brenda W Iddins
Issac E. Igbonagwam
Thomas Jackson
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Li Jiang
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Ellene Kebede
Ashley D. Kennedy
Constance A. Kersten
Jong Hwa Kim

Duk Kyung (Daniel) Kim
Steve Kimble
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Lawerence F. Koons
Larry K Krannich
Srinivasarao Krishnaprasad
Jeannc L. Kuhler
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Cherline Lee
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Michel G LeLong
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Christy Magrath
Fayequa Majid
Ken Roy Marion
Julia E. Massey
Juan Mata
Joseph Mathews Jr
William K McAllister
J Wayne McCain
Amanda McCall
Jim Mcclintock
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Teena M. McGuinness
Matthew McGuire
Ellen W. McLaughlin
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Lacoya Tyne Seltzer
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- The authors are encouraged to contact the editor (E-mail: sah@jsu.edu) prior to paper submission to obtain the guidelines for the author.
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- The author(s) should provide the names and addresses of at least two potential reviewers.
- Assemble the manuscript in the following order: Title Page, Abstract Page, Text, Brief acknowledgments (if needed), Literature Cited, Figure Legends, Tables, Figures.

What and Where to Submit:

The original and two copies of the manuscript and a cover letter should be submitted to the following.

Dr. Safaa Al-Hamdani
Editor-Alabama Academy of Science Journal
Biology Department
Jacksonville State University
700 Pelham Road North
Jacksonville, AL 36265-1602

Review Procedure and Policy:

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Biology Department
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